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(71) Applicant: U.S. SYNTHETIC CORPORATION [US/US]; 1260 South 1600 West, Orem, UT 84058 (US).

(72) Inventors: **MIESS, Davic**; 9639 N. 6220 West, Highland, UT 84003 (US). **KINKAID, Robert, G.**; 1748 S. 500 East, Orem, UT 84058 (US). **HARDY, John**; 2420 North Foothill Drive, Provo, UT 84604 (US).

(74) Agents: **SADLER, Lloyd, W.** et al.; McCarthy & Sadler, LC, Suite 100, 39 Exchange Place, Salt Lake City, UT 84111 (US).

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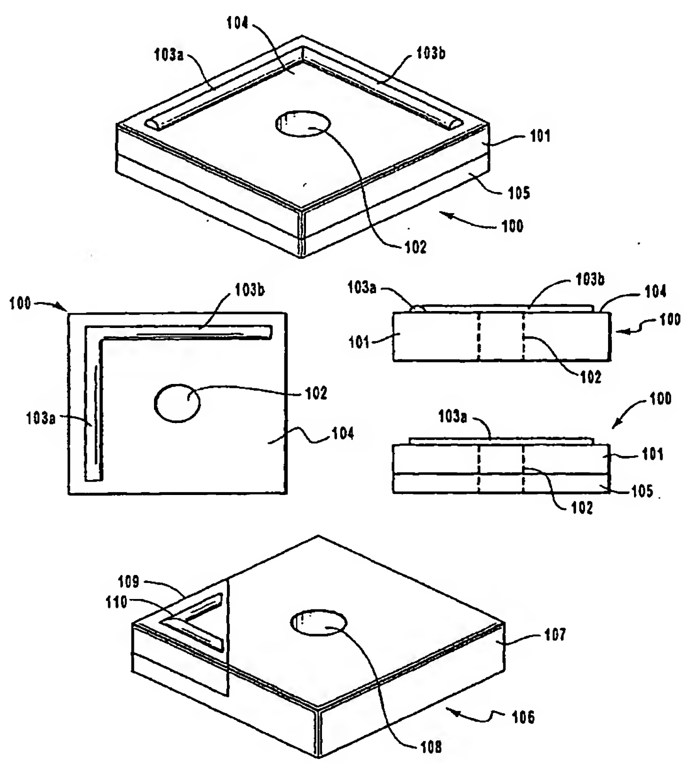
(54) Title: CHIP BREAKER DESIGN USING POLYCRYSTALLINE DIAMOND



(57) Abstract: Chip breaker design made from polycrystalline diamond to improve the operating life and the wear resistance of machine material tools (100). This invention incorporates new and useful complex shapes. In some preferred embodiments of this invention the polycrystalline diamond (101) is bonded to a tungsten carbide substrate (105) for improved cost performance and mounting capabilities.

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CHIP BREAKER DESIGN USING POLYCRYSTALLINE DIAMOND

To all whom it may concern:

Be it known that David Miess, Robert G. KinKaid and John W. Hardy, citizens of the United States of America, have invented a new and useful invention entitled CHIP BREAKER DESIGN USING POLYCRYSTALLINE DIAMOND of which the following comprises a complete specification.

CHIP BREAKER DESIGN USING POLYCRYSTALLINE DIAMOND

Background of the Invention

Field of the Invention. This invention relates to chip breakers used in the machining of materials. More particularly, this invention relates to chip breaker designs making use of a tungsten carbide substrate with a polycrystalline diamond surface to increase the working life of the chip breaker.

Description of the Related Art. A variety of chip breaker devices have been proposed for use in the machining of difficult materials to reduce the difficulties associated with long, stringy cuttings. Typically, these prior chip breakers are made of tungsten carbide, tungsten carbide with ceramic coatings, steel, stainless steel, aluminum and other metals. Some prior chip breakers have employed small amounts of polycrystalline diamond or polycrystalline diamond on limited surfaces of the chip breaker. However, prior chip breakers do not use tungsten carbide substrates with extensive use of polycrystalline diamond surface regions and which make use of complex cutter shapes impressed in the polycrystalline diamond regions, which features describe some of the novel aspects of this invention.

For general background material, the reader is directed to the following U.S. patents, each of which is incorporated by reference in its entirety for the material contained therein.

U.S. Patent No. 5,137,398 describes a drill bit having a substrate, mainly composed of Si3N4 or SiC, with a sintered diamond coating.

U.S. Patent No. 5,554,415 describes substrate coating techniques, including fabricating materials on a surface of a substrate, that uses energy, such as from one or more lasers, directed at the surface of the substrate to mobilize and vaporize a constituent element to alter its physical properties.

U.S. Patent No. 5,620,754 describes a method of treating and coating substrates that uses energy from one or more lasers to mobilize and vaporize a constituent element within the substrate to alter its physical structure.

U.S. Patent No. 5,635,243 describes a method of coating an organic substrate that uses energy from one or more lasers to mobilize and vaporize a constituent element to alter its physical structure.

U.S. Patent No. 5,643,641 describes a method of forming a diamond coating on a polymeric substrate that uses energy from one or more lasers to vaporize a constituent element to alter its physical structure.

U.S. Patent No. 5,648,127 describes a method of applying, sculpting, and texturing a coating on a substrate and for forming a heteroepitaxial coating on a surface of a substrate, that uses energy from one or more lasers to mobilize and vaporize a constituent element within the substrate to alter its physical structure.

U.S. Patent No. 5,709,907 describes a method of making a cutting tool, which comprises a substrate that has a roughened surface and a coating that is applied to the roughened surface of the substrate by physical vapor deposition.

U.S. Patent No. 5,722,803 describes a coated cutting tool and method of producing the same that provides improved chip control, improved surface finishing properties and/or improved coating adhesion.

U.S. Patent No. 5,772,366 describes a diamond-coated body of a wear resistant substrate with a surface coating, which body is suitable for wear parts and tools applications.

Summary of the Invention

It is desirable to provide a chip breaker tool for use in woodworking, machining, drilling and other like applications and which provides improved wear resistance, longer life, less friction and greater heat transfer properties than existing chip breakers. In particular, it is desirable to provide a chip breaker, which is made of either exclusively polycrystalline diamond or a polycrystalline diamond layer bonded to a substrate of tungsten carbide. Furthermore, it is desirable to have a chip breaker that employs complex shapes in the chip-breaking surface to enhance its ability to work on difficult materials.

Therefore, it is an object of this invention to provide a chip breaker design, which makes use of polycrystalline diamond to improve the operating characteristics of the chip breaker.

It is another object of the invention to provide a chip breaker design, which can use a tungsten carbide substrate bonded to the polycrystalline diamond material.

A further object of the invention is to provide a chip breaker design with the exterior edges polished to reduce friction.

A still further object of the invention is to provide a chip breaker design which makes use of non-planar interfaces to increase the thermal transfer of heat generated during the use of the chip breaker.

Another object of the invention is to provide a chip breaker design, which permits the use of wipers on angled parts.

It is a further object of the invention to provide a chip breaker design which permits a wide variety of geometric embodiments, including but not necessarily limited to square, triangular, rhombic, trigon, hexagonal, octagonal, pentagonal, rectangular, parallelogram, and round.

It is a still further object of the invention to provide a chip breaker design, which permits both single sided and double-sided embodiments.

It is another object of the invention to provide a chip breaker design which permits a wide variety of corner geometry tip options, including but not limited to flat, radius, wiper radius, sharp and two facet flats.

A still further object of this invention is to provide a chip breaker design which permits the use of a wide variety of gullets, including but not limited to continuous, non-continuous, concave, convex, constant width, varying width, constant depth, varying depth, radiused, equilateral triangle, angled, complex radius, square or rectangular, and mixed geometry.

Another object of this invention is to provide a chip breaker design, which permits the use of protrusions and ridges on the surface of the chip breaker.

These and other objects of this invention are accomplished by the chip breaker designs of this invention, which are readily apparent to those of ordinary skill in the art upon review of the following drawings, detailed description, claims and abstract.

Brief Description of the Drawings

In order to show the manner that the above recited and other advantages and objects of the invention are obtained, a more particular description of the various embodiments of this invention, which is illustrated in the appended drawings, is described as follows. The reader should understand that the drawings depict only a preferred embodiment of the invention, and are not to be considered as limiting the invention in scope. A brief description of the drawings is as follows:

Figure 1a is a perspective view of a first preferred embodiment of the invention.

Figure 1b is a top view of a first preferred embodiment of the invention.

Figure 1c is a side view of the first preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 1d is a side view of the first preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 1e is a perspective view of an alternative embodiment of this invention.

Figure 2a is a perspective view of an alternative preferred embodiment of the invention.

Figure 2b is a top view of an alternative preferred embodiment of the invention.

Figure 2c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 2d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 2e is a perspective view an alternative PDC breaker edge suitable for brazing to a substrate.

Figure 2f is a perspective view of the alternative PDC breaker edge brazed to a substrate.

Figure 3a is a perspective view of an alternative preferred embodiment of the invention.

Figure 3b is a top view of an alternative preferred embodiment of the invention.

Figure 3c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 3d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 3e is a perspective view of an alternative embodiment of the invention.

Figure 4a is a perspective view of an alternative preferred embodiment of the invention.

Figure 4b is a top view of an alternative preferred embodiment of the invention.

Figure 4c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 4d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 5a is a perspective view of an alternative preferred embodiment of the invention.

Figure 5b is a top view of an alternative preferred embodiment of the invention.

Figure 5c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 5d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 6a is a perspective view of an alternative preferred embodiment of the invention.

Figure 6b is a top view of an alternative preferred embodiment of the invention.

Figure 6c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 6d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 6e is a perspective view of an alternative embodiment of the invention.

Figure 6f is a side view of the alternative embodiment of figure 6e.

Figure 7a is a perspective view of an alternative preferred embodiment of the invention.

Figure 7b is a top view of an alternative preferred embodiment of the invention.

Figure 7c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 7d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figures 7e and 7f are side view of alternative embodiments of figure 7a.

Figure 8a is a perspective view of an alternative preferred embodiment of the invention.

Figure 8b is a top view of an alternative preferred embodiment of the invention.

Figure 8c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 8d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 8e is a perspective view of an alternative embodiment of the invention.

Figure 9a is a perspective view of an alternative preferred embodiment of the invention.

Figure 9b is a top view of an alternative preferred embodiment of the invention.

Figure 9c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 9d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figures 9e-g are side views showing alternative gullets that can be used with this invention.

Figure 10a is a perspective view of an alternative preferred embodiment of the invention.

Figure 10b is a top view of an alternative preferred embodiment of the invention.

Figure 10c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 10d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 11a is a perspective view of an alternative preferred embodiment of the invention.

Figure 11b is a top view of an alternative preferred embodiment of the invention.

Figure 11c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 11d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 12a is a perspective view of an alternative preferred embodiment of the invention.

Figure 12b is a top view of an alternative preferred embodiment of the invention.

Figure 12c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 12d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 12e is a perspective view of an alternative embodiment of this invention.

Figure 13a is a perspective view of an alternative preferred embodiment of the invention.

Figure 13b is a top view of an alternative preferred embodiment of the invention.

Figure 13c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 13d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 13e is a perspective view of an alternative embodiment of the invention.

Figure 13f is a side view of the alternative embodiment of figure 13e.

Figure 14a is a perspective view of an alternative preferred embodiment of the invention.

Figure 14b is a top view of an alternative preferred embodiment of the invention.

Figure 14c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 14d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 15a is a perspective view of an alternative preferred embodiment of the invention.

Figure 15b is a top view of an alternative preferred embodiment of the invention.

Figure 15c is a side view of an alternative preferred embodiment of the invention, using exclusively polycrystalline diamond.

Figure 15d is a side view of an alternative preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figures 15e and 15f are perspective views of alternative embodiments of this invention.

Figure 15g is a side view of the alternative embodiments of figures 15e and 15f.

Figure 16a is a perspective view of a first cylindrical preferred embodiment of the invention.

Figure 16b is a side view of the first cylindrical preferred embodiment of the invention.

Figure 16c is a top view of the first cylindrical preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 17a is a perspective view of an alternative cylindrical embodiment of the invention.

Figure 17b is a side view of an alternative cylindrical embodiment of the invention.

Figure 17c is a side view of an alternative cylindrical embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 17d is a perspective view of an alternative embodiment of the invention.

Figure 17e is a side view of the alternative embodiment of figure 17d.

Figure 18a is a perspective view of an alternative cylindrical preferred embodiment of the invention.

Figure 18b is a side view of an alternative cylindrical preferred embodiment of the invention.

Figure 18c is a top view of an alternative cylindrical preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 18d is a perspective view of an alternative embodiment of this invention.

Figures 18e,f are side views of alternative embodiments of figure 18d.

Figure 19a is a perspective view of an alternative cylindrical preferred embodiment of the invention.

Figure 19b is a side view of an alternative cylindrical embodiment of the invention.

Figure 19c is a side view of an alternative cylindrical embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figures 19d and 19e are perspective views of alternative embodiments of this invention.

Figures 19f and 19g are side view of the embodiment shown in figures 19d and 19e.

Figure 20a is a perspective view of an alternative cylindrical preferred embodiment of the invention.

Figure 20b is a side view of an alternative cylindrical preferred embodiment of the invention.

Figure 20c is a top view of an alternative cylindrical preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 21a is a perspective view of an alternative cylindrical preferred embodiment of the invention.

Figure 21b is a side view of an alternative cylindrical preferred embodiment of the invention.

Figure 21c is a side view of an alternative cylindrical preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 21d is a perspective view of the tool of figure 21a brazed to a tool.

Figure 21e is a side view of alternative figure 21d having a positive gullet.

Figure 21f is a side view of alternative figure 21d having a negative gullet.

Figure 22a is a perspective view of an alternative cylindrical preferred embodiment of the invention.

Figure 22b is a side view of an alternative cylindrical preferred embodiment of the invention.

Figure 22c is a top view of an alternative cylindrical preferred embodiment of the invention, using a polycrystalline diamond layer bonded to a tungsten carbide substrate.

Figure 23 is a perspective view of a first triangular preferred embodiment of the invention.

Figure 24 is a perspective view of an alternative triangular preferred embodiment of the invention.

Figure 25 is a perspective view of an alternative triangular preferred embodiment of the invention.

Figure 26a is a perspective view of an alternative triangular preferred embodiment of the invention.

Figure 26b is a perspective view of an alternative triangular embodiment brazed on a chip breaker of this invention.

Figure 26c is a perspective view of an alternative triangular embodiment brazed on a chip breaker of this invention.

Figure 26d is a perspective view of an alternative triangular embodiment brazed on a chip breaker of this invention.

Figure 26e is a perspective view of an alternative chip breaker suitable for brazing on a chip breaker of this invention.

Figure 27 is a perspective view of a first preferred rectangular embodiment of the invention.

Figure 28 is a perspective view of an alternative rectangular preferred embodiment of the invention.

Figure 29 is a perspective view of an alternative rectangular preferred embodiment of the invention.

Figure 30 is a perspective view of an alternative rectangular preferred embodiment of the invention.

Figure 31 is a perspective view of an alternative rectangular preferred embodiment of the invention.

Figure 32 is a perspective view of an alternative rectangular preferred embodiment of the invention.

Figure 33 is a perspective view of an alternative preferred embodiment of the invention.

Figure 33a is a perspective view of an alternative embodiment of the invention.

Figure 33b is a perspective view of the alternative embodiment of figure 33a of this invention brazed to a tool.

Figure 33c is a perspective view of a further alternative embodiment of this invention.

Figure 33d is a perspective view of a still further alternative embodiment of this invention.

Figure 33e is a side view of an alternative embodiment of this invention.

Figure 34 is a perspective view of an alternative preferred embodiment of the invention.

Figure 35 is a perspective view of an alternative preferred embodiment of the invention.

Figure 36 is a perspective view of an alternative preferred embodiment of the invention.

Figure 37 is a perspective view of an alternative preferred embodiment of the invention.

Figure 38 is a perspective view of an alternative preferred embodiment of the invention.

Figure 39a is a side view of one preferred insert type of the invention.

Figure 39b is a side view of a second preferred insert type of the invention.

Figure 39c is a side view of a third preferred insert type of the invention.

Figure 39d is a side view of a fourth preferred insert type of the invention.

Figure 40a is a top detail view of a flat corner tip of the invention.

Figure 40b is a top detail view of a radius corner tip of the invention.

Figure 40c is a top detail view of a wiper radius corner tip of the invention.

Figure 40d is a top detail view of a sharp corner tip of the invention.

Figure 40e is a top detail view of a two-facet flat corner tip of the invention.

Figures 41a-r are side views of various alternative gullet designs of this invention.

Figures 42a-k are side view of various alternative edge details of this invention.

Figure 43a is a side view of an alternative configuration of this invention having PDC regions on each side of the tungsten carbide region.

Figure 43b is a side view of a second alternative configuration of this invention.

Figure 44 is a side view showing an alternative use of spokes and gullet in this invention.

Figures 45a-c show side view of alternative rake angle variations in this invention.

Figures 46a-l show side and top view of various alternative triangular chip breaker embodiments of this invention.

Figure 47 is a perspective view of an alternative embodiment of the preferred chip breaker of this invention.

Figure 48 is a perspective view of another alternative embodiment of the preferred chip breaker of this invention.

Detailed Description of the Invention

This invention is a chip breaker, for use in the machining of difficult materials that create high wear, that makes use of Polycrystalline diamond (PDC) material to provide a wear resistant super hard cutting surface. Referring now to the figures, which provide detailed drawings of the various embodiments of this invention as well as the detailed views of specific geometric features of this invention.

Figure 1a shows a perspective view of a first preferred embodiment of the invention. This embodiment 100 has a PDC top surface 101 bonded to a tungsten carbide substrate 105. The use of the tungsten carbide substrate 105 is optional and may not be used in alternative embodiments of the invention. A positive or convex gullet 103a,b is provided on the top surface 104 of the PDC top surface 101. This gullet 103a,b runs generally parallel to two of the edges of the chip breaker 100. A central hole 102 is also optionally provided as a mounting point.

Figure 1b shows the top view of the first preferred embodiment 100 of the invention. This view shows the relative positioning of the gullet 103a,b on the top surface 104 of the chip breaker 100.

Figure 1c shows the side view of another alternative of the present preferred embodiment 100 of the invention, made only of polycrystalline diamond 101 without the tungsten carbide substrate 105.

Figure 1d shows a second side view of the first preferred embodiment 100 of the invention, using a polycrystalline diamond layer 101 bonded to a tungsten carbide substrate 105.

Figure 1e shows a perspective view of an alternative embodiment of this invention 106 with a chip breaker portion 109 brazed or otherwise fixed to a substrate 107 or tool. Optionally, the substrate 107 is provided with a central hole 108 as a mounting point. The chip breaker portion 109 has a gullet 110 providing additional abrasion to the work piece.

Figure 2a shows a perspective view of an alternative preferred embodiment of the invention. This embodiment 200 has a PDC top surface 201 bonded to a tungsten carbide substrate 205. The use of the tungsten carbide substrate 205 is optional and may not be used in alternative embodiments of the invention. A negative or concave gullet 203a,b is provided in the top surface 204 of the PDC top surface 201. This gullet 203a,b runs within the top surface 204 and generally parallel to two of the edges of the chip breaker 200. Optionally, a central hole 202 can also be provided as a mounting point.

Figure 2b shows the top view of an alternative preferred embodiment 200 of the invention. This view shows the relative positioning of the gullet 203a,b in the top surface 204 of the chip breaker 200.

Figure 2c shows the side view of another alternative of the present preferred embodiment 200 of the invention, made only of polycrystalline diamond 201 without the tungsten carbide substrate 205.

Figure 2d shows a second side view of an alternative preferred embodiment 200 of the invention, using a polycrystalline diamond layer 201 bonded to a tungsten carbide substrate 205.

Figure 2e shows an "L-shaped" cutter section 206 composed of a polycrystalline diamond layer 208 brazed or otherwise fixed to a tungsten carbide layer 209 which in turn in fixed to a tungsten carbide substrate 210. A gullet 207 is provided on the top surface 213 of the cutter section 206 to provide additional abrasion qualities.

Figure 2f shows the "L-shaped" cutter section 206 of figure 2e brazed or otherwise mounted to a tool portion 211. Optionally, the tool portion 211 is provided with an opening 212 for a mounting point.

Figure 3a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 300 has a PDC top surface 301 bonded to a tungsten carbide substrate 305. The use of the tungsten carbide substrate 305 is optional and may not be used in alternative embodiments of the invention. A top surface edge 308 with positive gullet 307 and a top plane 309 are provided on the top surface 304 of the PDC top surface 301. A number of chip splitters 306a,b,c,d are

positioned near each corner of the top plane 309. The protuberances making up each chip splitter 306a,b,c,d are shown having three "toes." In alternative embodiments, one or more "toes" can be substituted. A central hole 302 is also provided as a mounting point.

Figure 3b shows the top view of an alternative preferred embodiment 300 of the invention. This view shows the relative positioning of the top surface edge 308, the gullet 307, the top plane 309 and the chip splitters 306a,b,c,d on the top surface 304 of the chip breaker 300.

Figure 3c shows the side view of another alternative of the present preferred embodiment 300 of the invention, made only of polycrystalline diamond 301 without the tungsten carbide substrate 305. This view shows vertical elevation of the top surface edge 308, the gullet 307 and the top plane 309 on the top surface 304.

Figure 3d shows a second side view of an alternative preferred embodiment 300 of the invention, using a polycrystalline diamond layer 301 bonded to a tungsten carbide substrate 305.

Figure 3e shows a perspective view of an alternative embodiment 310 having four negative or concave gullets 312a,b,c,d with protuberances 313a,b,c,d at the corners and between the gullets 312a,b,c,d. In alternative embodiments a different number of gullets may be used.

Figure 4a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 400 has a PDC top surface 401 bonded to a tungsten carbide substrate 402. The use of the tungsten carbide substrate 402 is optional and may not be used in alternative embodiments of the invention. A

top surface edge 403 with negative slope 404 and an interior plane 405 are provided on the PDC top surface 401. Four notches 407a,b,c,d are positioned near the center of each side of the PDC surface 401. A central hole 406 is also provided as a mounting point.

Figure 4b shows the top view of an alternative preferred embodiment 400 of the invention. This view shows the relative positioning of the top surface edge 403, the negative slope 404, the internal plane 405 and the notches 407a,b,c,d on the PDC top surface 401 of the chip breaker 400.

Figure 4c shows the side view of another alternative of the present preferred embodiment 400 of the invention, made only of polycrystalline diamond 401 without the tungsten carbide substrate 402. This view shows depression of the interior plane 404 within the PDC region 401.

Figure 4d shows a second side view of an alternative preferred embodiment 400 of the invention, using a polycrystalline diamond layer 401 bonded to a tungsten carbide substrate 402.

Figure 5a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 500 has a PDC top surface 501 bonded to a tungsten carbide substrate 502. The use of the tungsten carbide substrate 502 is optional and may not be used in alternative embodiments of the invention. A top surface edge 503 with positive slope 504 and a top plane 505 are provided on the PDC top surface 501. Eight round or radius corners 507a-h are positioned near the center of each side and near the corners of the PDC surface 501. A central hole 506 is also provided as a mounting point.

Figure 5b shows the top view of an alternative preferred embodiment 500 of the invention. This view shows the relative positioning of the top surface edge 503, the positive slope 504, the top plane 505 and the rounded corners 507a-h on the PDC top surface 501 of the chip breaker 500.

Figure 5c shows the side view of another alternative of the present preferred embodiment 500 of the invention, made only of polycrystalline diamond 501 without the tungsteh carbide substrate 502. This view shows the elevation of the interior plane 504 within the PDC region 501.

Figure 5d shows a second side view of an alternative preferred embodiment 500 of the invention, using a polycrystalline diamond layer 501 bonded to a tungsten carbide substrate 502.

Figure 6a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 600 has a PDC top surface 601 bonded to a tungsten carbide substrate 602. The use of the tungsten carbide substrate 602 is optional and may not be used in alternative embodiments of the invention. A top surface edge 603 and a sloped gullet 604 leading to the top plane 605 are provided on the PDC top surface 601. The top plane 605 of this embodiment of the invention is offset from the generally square shape of the top surface edge 603. A central hole 606 is also provided as a mounting point.

Figure 6b shows the top view of an alternative preferred embodiment 600 of the invention. This view shows the relative positioning of the top surface edge 603, the positive sloped gullet 604, the top plane 605 PDC top surface 601 of the chip breaker 600.

Figure 6c shows the side view of another alternative of the present preferred embodiment 600 of the invention, made only of polycrystalline diamond 601 without the tungsten carbide substrate 602. This view shows the elevation of the gullet 604 and the interior plane 605 within the PDC region 601.

Figure 6d shows a second side view of an alternative preferred embodiment 600 of the invention, using a polycrystalline diamond layer 601 bonded to a tungsten carbide substrate 602.

Figure 6e shows an alternative embodiment 607 having a negative concave gullet 608 surrounding the top plane 609 of the chip breaker 607. A mounting hole 610 is provided as an option.

Figure 6f shows a side view of the alternative embodiment of figure 6e showing the gullet 608 in relation to the top plane 609.

Figure 7a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 700 has a PDC top surface 701 bonded to a tungsten carbide substrate 702. The use of the tungsten carbide substrate 702 is optional and may not be used in alternative embodiments of the invention. A top surface edge 703 and a number of rounded scallops or protuberances 704 are provided atop this chip breaker. An interior plain 705 is provided within the protuberances 704.

Figure 7b shows the top view of this alternative preferred embodiment 700 of the invention. This view shows the relative positioning of the top surface edge 703, the protuberances 704 and the interior plain 705 on the top PDC region 701 of the chip breaker 700.

Figure 7c shows the side view of another alternative of the present preferred embodiment 700 of the invention, madė only of polycrystalline diamond 701 without the tungsten carbide substrate 702. This view shows the elevation profile of the protuberances 704.

Figure 7d shows a second side view of an alternative preferred embodiment 700 of the invention, using a polycrystalline diamond layer 701 bonded to a tungsten carbide substrate 702.

Figure 7e shows a side view of an alternative embodiment of the embodiment of figure 7a having a top plane 707, which is higher than the outside edge 712, and with a negative gullet or scallops 708 provided set back from the outside edge 712.

Figure 7f shows a side view of another alternative embodiment 709 where the protuberances 710 provide the top plane 713 where the gullet 711 reaches to the edge 714 of the chip breaker 709.

Figure 8a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 800 has a PDC top surface 801 bonded to a tungsten carbide substrate 802. The use of the tungsten carbide substrate 802 is optional and may not be used in alternative embodiments of the invention. A top surface edge 803, a plurality of non-continuous convex gullets 804, and a continuous concave gullet 805 are provided on the PDC top surface 801. The top plane 807 of this embodiment of the invention is generally at the same elevation as the top surface edge 803. A central hole 806 is also provided as a mounting point. In further alternative embodiments of this present embodiment the convex gullets 804

can be substituted with similar concave gullets and the concave gullet 805 can be substituted with a similar convex gullet.

Figure 8b shows the top view of this alternative preferred embodiment 800 of the invention. This view shows the relative positioning of the gullets 804, 805 on the top PDC region 801 of the chip breaker 800. Protuberances 808 and 809 are provided to act as chip folders for on ether side of the gullets 804.

Figure 8c shows the side view of another alternative of the present preferred embodiment 800 of the invention, made only of polycrystalline diamond 801 without the tungsten carbide substrate 802. This view shows the elevation profile of the convex gullets 804.

Figure 8d shows a second side view of an alternative preferred embodiment 800 of the invention, using a polycrystalline diamond layer 801 bonded to a tungsten carbide substrate 802.

Figure 8e shows a perspective view of an alternative embodiment of this invention 810 having negative or concave gullets 813. This view also shows the PDC layer brazed or otherwise fixed to a tungsten carbide layer 812.

Figure 9a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 900 has a PDC top surface 901 bonded to a tungsten carbide substrate 902. The use of the tungsten carbide substrate 902 is optional and may not be used in alternative embodiments of the invention. A top surface edge 903, a first chip breaker edge 904 and a second chip breaker edge 905, leading to the top plane 906 are provided on the PDC top surface 901. The top

plane 906 of this embodiment of the invention is generally inset and parallel to the top surface edge 903. A central hole 907 is also provided as a mounting point.

Figure 9b shows the top view of this alternative preferred embodiment 900 of the invention. This view shows the relative positioning of the edges 904, 905 on the top PDC region 901 of the chip breaker 900.

Figure 9c shows the side view of another alternative of the present preferred embodiment 900 of the invention, made only of polycrystalline diamond 901 without the tungsten carbide substrate 902. This view shows the elevation profile of the edges 904, 905 and the top plane 906.

Figure 9d shows a second side view of an alternative preferred embodiment 900 of the invention, using a polycrystalline diamond layer 901 bonded to a tungsten carbide substrate 902.

Figure 9e shows an alternative side view of this embodiment 980. In this embodiment a negative gullet 909 extends from the top plane 910. Optionally a mounting hole 911 is provided.

Figure 9f shows another alternative embodiment 912 having a positive gullet 913 surrounding the top plane 914. Again, an optional mounting hole 915 is provided.

Figure 9g shows a still further alternative embodiment 916 of the invention having a gullet 917 which extends to the edge 920 of the chip breaker 916 from the top plane 918.

Figure 10a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 1000 has a PDC top surface 1001

bonded to a tungsten carbide substrate 1002. The use of the tungsten carbide substrate 1002 is optional and may not be used in alternative embodiments of the invention. A top surface edge 1007, a first chip breaker edge 1004 and a second non planar serrated chip breaker edge 1003, leading to the top plane 1005 are provided on the PDC top surface 1001. The top plane 1005 of this embodiment of the invention is generally inset and parallel to the top surface edge 1007. A central hole 1006 is also provided as a mounting point. While this figure shows only one serrated edge 1003, in alternative embodiments each edge can be similarly serrated.

Figure 10b shows the top view of this alternative preferred embodiment 1000 of the invention. This view shows the relative positioning of the edges 1007, 1003 on the top PDC region 1001 of the chip breaker 1000.

Figure 10c shows the side view of another alternative of the present preferred embodiment 1000 of the invention, made only of polycrystalline diamond 1001 without the tungsten carbide substrate 1002. This view shows the elevation profile of the edges 1007, 1004, 1003 and the top plane 1005.

Figure 10d shows a second side view of an alternative preferred embodiment 1000 of the invention, using a polycrystalline diamond layer 1001 bonded to a tungsten carbide substrate 1002.

Figure 11a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 1100 has a PDC top surface 1101 bonded to a tungsten carbide substrate 1102. The use of the tungsten carbide substrate 1102 is optional and may not be used in alternative embodiments of the invention. A top surface edge 1103, an upwardly sloped breaker edge 1104 and a top

surface 1105 is provided. In this embodiment, the top surface 1105 has four generally triangularly shaped portions 1107a-d. A central hole 1106 is also provided as a mounting point.

Figure 11b shows the top view of this alternative preferred embodiment 1100 of the invention. This view shows the relative positioning of the edge 1104 and the top surface 1105of the PDC region 1101 of the chip breaker 1100.

Figure 11c shows the side view of another alternative of the present preferred embodiment 1100 of the invention, made only of polycrystalline diamond 1101 without the tungsten carbide substrate 1102. This view shows the elevation profile of the edge 1104 and the top plane 1005.

Figure 11d shows a second side view of an alternative preferred embodiment 1100 of the invention, using a polycrystalline diamond layer 1101 bonded to a tungsten carbide substrate 1102.

Figure 12a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 1200 has a PDC top surface 1201 bonded to a tungsten carbide substrate 1202. The use of the tungsten carbide substrate 1202 is optional and may not be used in alternative embodiments of the invention. A top surface edge 1203, a plurality of concave gullet chip splitters 1204, an edge 1205 leading to a top surface 1206 is provided. A central hole 1207 is also provided as a mounting point.

Figure 12b shows the top view of this alternative preferred embodiment 1200 of the invention. This view shows the relative positioning of the gullets 1204, the edge 1205 and the top surface 1206 of the PDC region 1201 of the chip breaker 1200.

Figure 12c shows the side view of another alternative of the present preferred embodiment 1200 of the invention, made only of polycrystalline diamond 1201 without the tungsten carbide substrate 1202. This view shows the elevation profile of the edge 1205, the depressions from the concave gullets 1205 and the top plane 1206.

Figure 12d shows a second side view of an alternative preferred embodiment 1200 of the invention, using a polycrystalline diamond layer 1201 bonded to a tungsten carbide substrate 1202.

Figure 12e shows an alternative embodiment 1207 having positive protuberances 1203 placed on the top surface 1210. An optional mounting hole 1209 is provided.

Figure 13a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 1300 has a PDC top surface 1301 bonded to a tungsten carbide substrate 1302. The use of the tungsten carbide substrate 1302 is optional and may not be used in alternative embodiments of the invention. A top surface edge 1303, four separate convex, or in alternative embodiments concave, gullets 1304a-d are provided. A central hole 1305 is also provided as a mounting point.

Figure 13b shows the top view of this alternative preferred embodiment 1300 of the invention. This view shows the relative positioning of the gullets 1304a-d on the top surface 1303 of the PDC region 1301 of the chip breaker 1300.

Figure 13c shows the side view of another alternative of the present preferred embodiment 1300 of the invention, made only of polycrystalline diamond 1301

without the tungsten carbide substrate 1302. This view shows the elevation profile of the gullets 1304a-d.

Figure 13d shows a second side view of an alternative preferred embodiment 1300 of the invention, using a polycrystalline diamond layer 1301 bonded to a tungsten carbide substrate 1302.

Figure 13e shows an alternative embodiment 1306, similar to the embodiment of figure 13a, but only having two gullets 1307a,b.

Figure 13f is a side view of the embodiment 1306 of figure 13e showing the relative position of the gullets 1307a,b and the optional mounting hole 1308.

Figure 14a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 1400 has a PDC top surface 1401 bonded to a tungsten carbide substrate 1402. The use of the tungsten carbide substrate 1402 is optional and may not be used in alternative embodiments of the invention. A top surface edge 1403, a first planar region 1404, a second edge 1405, and a top planar region 1406 are provided. A central hole 1407 is also provided as a mounting point.

Figure 14b shows the top view of this alternative preferred embodiment 1400 of the invention. This view shows the relative positioning of the top planar region 1406 on the PDC region 1401 of this chip breaker 1400. The first planar region 1404 may be either flush with the edge 1403 or may be concave.

Figure 14c shows the side view of another alternative of the present preferred embodiment 1400 of the invention, made only of polycrystalline diamond 1401

without the tungsten carbide substrate 1402. This view shows the elevation profile of the top planar region 1406.

Figure 14d shows a second side view of an alternative preferred embodiment 1400 of the invention, using a polycrystalline diamond layer 1401 bonded to a tungsten carbide substrate 1402.

Figure 15a shows a perspective view of another alternative preferred embodiment of the invention. This embodiment 1500 has a PDC top surface 1501 bonded to a tungsten carbide substrate 1502. The use of the tungsten carbide substrate 1502 is optional and may not be used in alternative embodiments of the invention. A top surface

1504 and four chip splitter protuberances 1503a-d are provided. An alternative number of protuberances 1503a-d may be substituted with either more or less protuberances without departing from the concept of the invention.

Figure 15b shows the top view of this alternative preferred embodiment 1500 of the invention. This view shows the relative positioning of the four-chip splitter protuberances 1503a-d on the top surface 1504 on the PDC region 1501 of this chip breaker 1500.

Figure 15c shows the side view of another alternative of the present preferred embodiment 1500 of the invention, made only of polycrystalline diamond 1501 without the tungsten carbide substrate 1502. This view shows the elevation profile of the chip splitter protuberances on the top surface 1504.

Figure 15d shows a second side view of an alternative preferred embodiment 1500 of the invention, using a polycrystalline diamond layer 1501 bonded to a tungsten carbide substrate 1502.

Figure 15e shows an alternative embodiment 1504 of figure 15a having cavities 1505a,b,c,d rather than protuberances.

Figure 15f shows the alternative embodiment of figure 15e with the cavities 1507a,b in a PDC region 1509a,b bonded to a second tungsten carbide layer 1510a,b, which is brazed or otherwise mounted to a tool substrate 1511.

Figure 15g shows a side view of the alternative embodiment 1508 of figure 15f.

Figure 16a is a perspective view of a first round alternative chip breaker 1600 of this invention. This embodiment 1600 has a polycrystalline diamond layer 1601 bonded to a tungsten carbide substrate 1602. In alternative embodiments this part may be made without a tungsten carbide substrate 1602 as a solid PDC part. A first machined edge 1603, a simple recessed gullet 1604 and a center land 1605, shown with an optional clamping hole 1606 is provided. The center land 1605 can be higher, the same level, or lower than the outside machined edge 1603.

Figure 16b is a side view of this present first round embodiment 1600 of the invention. The recessed gullet 1604 is shown in dashed lines.

Figure 16c is a top view of this present first round embodiment of the invention 1600, showing the relative positions of the first machined edge 1603, the recessed gullet 1604, the center land 1605 and the clamping hole 1606.

Figure 17a is a perspective view of another round alternative chip breaker 1700 of this invention. This embodiment 1700 has a polycrystalline diamond layer 1701 bonded to a tungsten carbide substrate 1702. In alternative embodiments this part may be made without a tungsten carbide substrate 1702 as a solid PDC part. Eight 1705a-h chip splitter spokes with eight intervening gullets 1704a-h are provided within a machined edge 1703, along with a center land 1706 having the optional clamping hole 1707.

Figure 17b is a side view of this present alternative round embodiment 1700 of the invention. The recessed gullets 1704a-h are shown in dashed lines.

Figure 17c is a top view of this present alternative round embodiment of the invention 1700, showing the relative positions of the first machined edge 1703, the recessed gullets 1704a-h and the chip splitter spokes 1705a-h, along with the center land 1706 and the clamping hole 1707.

Figure 17d shows a perspective view of an alternative embodiment 1708 of that shown in figure 17a wherein the center land 1709 is higher than the outside edge 1711. The protuberances 1710 bridge the gaps 1712 to the outside edge 1711.

Figure 17e shows the side view of the embodiment 1708 of figure 17d. The center land 1709 is shown in relation to the protuberances 1710 and the outside edge 1711.

Figure 18a is a perspective view of another round alternative chip breaker 1800 of this invention. This embodiment 1800 has a polycrystalline diamond layer 1801 bonded to a tungsten carbide substrate 1802. In alternative embodiments this part may be made without a tungsten carbide substrate 1802 as a solid PDC part.

Eight stand-alone protuberances 1805a-h are provided within a recessed gullet 1804, all of which is positioned within a machined edge 1803. A chip breaker land 1806 is also provided, generally in the center of the top surface of the round chip breaker of this embodiment 1800.

Figure 18b is a side view of this present alternative round embodiment 1800 of the invention. The recessed gullet 1804 is shown in dashed lines.

Figure 18c is a top view of this present alternative round embodiment of the invention 1800, showing the relative positions of the stand-alone protuberances 1805a-h and the recessed gullet 1804, as well as the machined edge 1803and the chip breaker land 1806.

Figure 18d shows an alternative embodiment where the chip breaker land 1806 has a higher elevation than the outer edge 1803.

Figure 18e shows the side view of the embodiment of figure 18a where the chip breaker land 1806 is of similar elevation to the outer edge 1803.

Figure 18f shows the side view of the embodiment of figure 18d where the chip breaker land 1806 is higher than the outer edge 1803.

Figure 19a is a perspective view of another round alternative chip breaker 1900 of this invention. This embodiment 1900 has a polycrystalline diamond layer 1901 bonded to a tungsten carbide substrate 1902. In alternative embodiments this part may be made without a tungsten carbide substrate 1902 as a solid PDC part. A single off-center chip land 1905 is provided within a recessed gullet 1904. Preferably, this gullet 1904 increases in depth as well as width. The gullet 194 is encircled by a flat-machined edge 1903.

Figure 19b is a side view of this present alternative round embodiment 1900 of the invention. The recessed gullet 1904 and the off-center chip land 1905 are shown in dashed lines.

Figure 19c is a top view of this present alternative round embodiment of the invention 1900, showing the relative positions of the first machined edge 1903, the recessed gullet 1904 and the off-center chip land 1905.

Figure 19d shows a perspective view of another embodiment of the chip breaker of figure 19a where the center land 1907, having an optional mounting hole 1908. A ridge 1912 is generally flat, with no gullet design in this embodiment.

Figure 19e shows a perspective view of an alternative embodiment 1911 of the chip breaker of figure 19a, where an asymmetrical gullet 1909 within the outer edge 1910. A center hole 1905 is optionally provided for mounting.

Figure 19f is a side view of the embodiment of figure 19d showing the relative positions of the center land 1907 and the generally flat ridge 1912.

Figure 19g is a side view of the embodiment of figure 19e showing the cross section 1913, 1914 of the gullet 1909.

Figure 20a is a perspective view of another round alternative chip breaker 2000 of this invention. This embodiment 2000 has a polycrystalline diamond layer 2001 bonded to a tungsten carbide substrate 2002. In alternative embodiments this part may be made without a tungsten carbide substrate 2002 as a solid PDC part. Ten stand-alone protuberances 2005a-j are provided within a recessed gullet 2004, all of which is positioned within a machined edge 2003. The protuberances 2005 are non-uniformly grouped within the gullet 2004. A chip breaker land 2006 is also provided,

generally in the center of the top surface of the round chip breaker of this embodiment2000.

Figure 20b is a side view of this present alternative round embodiment 2000 of the invention. The recessed gullet 2004 and the chip breaker land 2006 are shown in dashed lines.

Figure 20c is a top view of this present alternative round embodiment of the invention 2000, showing the relative positions of the stand alone protuberances 2005a-j and the recessed gullet 2004, as well as the machined edge 2003 and the chip breaker land 2006.

Figure 21a is a perspective view of another round alternative chip breaker 2100 of this invention. This embodiment 2100 has a polycrystalline diamond layer 2101 bonded to a tungsten carbide substrate 2102. In alternative embodiments this part may be made without a tungsten carbide substrate 2102 as a solid PDC part. A chip land 2104 is provided with a partial gullet 2105. This chip land 2104 can vary in height, although the preferred embodiment has the chip land 2104 flush with the machined outer edge 2103.

Figure 21b is a side view of this present alternative round embodiment 2100 of the invention. The partial recessed gullet 2105 and the chip land 2104 are shown in dashed lines.

Figure 21c is a top view of this present alternative round embodiment of the invention 2100, showing the relative positions of the first machined edge 2103, the partial recessed gullet 2105 and the off-center chip land 2104.

Figure 21d is a perspective drawing of the chip breaker 2100 of figure 21a brazed to a tool 2106.

Figure 21e is a side view of the chip breaker 2100 showing a positive gullet 2107.

Figure 21f is a side view of the chip breaker 2100 showing a negative gullet 2110, 2111.

Figure 22a is a perspective view of another round alternative chip breaker 2200 of this invention. This embodiment 2200 has a polycrystalline diamond layer 2201 bonded to a tungsten carbide substrate 2202. In alternative embodiments this part may be made without a tungsten carbide substrate 2202 as a solid PDC part. Six 2205a-f angled chip splitter spokes with six intervening gullets 2204a-f are provided within a machined edge 2203, along with a center land 2206.

Figure 22b is a side view of this present alternative round embodiment 2200 of the invention.. The recessed gullets 2204a-f are shown in dashed lines.

Figure 22c is a top view of this present alternative round embodiment of the invention 2200, showing the relative positions of the first machined edge 2203, the recessed gullets 2204a-f and the angled chip splitter spokes 2205a-f, along with the center land 2206.

Figure 22d shows a perspective view of an alternative embodiment of the chip breaker 220o of figure 22a. This embodiment 2207 has a center land 2206 at a higher elevation that the outer periphery 2213. A number of spiral spokes 2209a-d forming a bridge between the center land 2206 and the outer periphery 2213, over a number of concave gullets 2210a-d.

Figure 23 is a perspective view of a first triangular embodiment 2300 of the invention. This embodiment 2300 is shown as a solid polycrystalline diamond chip breaker, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the PDC region. A flat machined edge 2302 is provided around the periphery of the chip breaker 2300. A concave gullet 2303 is provided in the top surface, surrounding a center chip land 2304.

Figure 24 is a perspective view of another triangular embodiment 2400 of the invention. This embodiment 2400 is shown as a solid polycrystalline diamond chip breaker, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the PDC region. A flat machined edge 2402 is provided around the periphery of the chip breaker 2400. A concave gullet 2403, with a plurality of chip splitter protuberances 2404, is provided in the top surface, surrounding a center chip land 2405.

Figure 25 is a perspective view of a first triangular embodiment 2500 of the invention. This embodiment 2500 is shown as a solid polycrystalline diamond chip breaker, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the PDC region. A flat machined edge 2502 is provided around the periphery of the chip breaker 2500. A concave gullet 2503 is provided in the top surface, with a plurality of spokes 2504 extending from a center chip land 2505 to the machined edge 2502.

Figure 26a is a perspective view of a first triangular embodiment 2600 of the invention. This embodiment 2600 is shown as a solid polycrystalline diamond chip breaker, although in alternative embodiments, a tungsten carbide substrate can be

bonded to the bottom of the PDC region. A flat machined top surface 2603 is provided with a single chip splitter 2602 protuberance on its surface.

Figure 26b shows a triangular chip breaker 2605 brazed to a tool substrate 2605, typically made of tungsten carbide, making a tool assembly 2604. The tool 2604 is shown provided with the optional mounting hole 2608. The triangular chip breaker 2605 is shown having a PDC layer 2606 brazed to a tungsten carbide layer 2607.

Figure 26c shows a triangular chip breaker 2614 brazed to a tool substrate 2610, typically made of tungsten carbide, making a tool assembly 2609. The tool 2609 is shown provided with the optional mounting hole 2613. The triangular chip breaker 2614 is shown having a PDC layer 2611 brazed to a tungsten carbide layer 2612.

Figure 26d shows a triangular chip breaker 2617 brazed to a tool substrate 2620, typically made of tungsten carbide, making a tool assembly 2621. The tool 2621 is shown provided with the optional mounting hole 2620. The triangular chip breaker 2617 is shown having a PDC layer 2618 brazed to a tungsten carbide layer 2619. This embodiment 2621 has a top surface 2616 recessed in the tool 2621, with an inner edge 2615.

Figure 26e shows the PDC insert 2617 of figure 26d, providing additional details showing the relative position of the PDC layers 2618 on a tungsten carbide layer 2619.

Figure 27 is a perspective view of a first square grooving tool embodiment 2700 of the invention. This embodiment 2700 is shown as a solid polycrystalline

diamond tool 2701, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A plurality of raised chip splitters 2702a,b,c are provided in the top surface 2703 of the tool 2700.

Figure 28 is a perspective view of another square grooving tool embodiment 2800 of the invention. This embodiment 2800 is shown as a solid polycrystalline diamond tool 2801, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A plurality of rounded raised chip splitters 2802a,b are provided in the top surface 2803 of the tool 2800.

Figure 29 is a perspective view of another square grooving tool embodiment 2900 of the invention. This embodiment 2900 is shown as a solid polycrystalline diamond tool 2901, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A chip folder 2902 with a splitter 2904 is provided in the top surface 2903 of the tool 2900.

Figure 30 is a perspective view of another square grooving tool embodiment 3000 of the invention. This embodiment 2300 is shown as a solid polycrystalline diamond tool 3001, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A plurality of concave gullets 3002a,b are provided in the top edges 3003a,b of the tool 3000.

Figure 31 is a perspective view of another square grooving tool embodiment 3100 of the invention. This embodiment 3100 is shown as a solid polycrystalline diamond tool 3101, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A plurality of concave gullets 3102a,b are provided in top edges 3103a,b of the tool 3100.

Figure 32 is a perspective view of another square grooving tool embodiment 3200 of the invention. This embodiment 3200 is shown as a solid polycrystalline diamond tool 3201, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A raised ridge 3202 is provided in the top surface 3203 of the tool 3200.

Figure 33 is a perspective view of another square grooving tool embodiment 3300 of the invention. This embodiment 3300 is shown as a solid polycrystalline diamond tool 3301, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A plurality of gullets 3302a,b are provided in the top surface 3303 of the tool 3300.

Figure 33a is a perspective view of an alternative square grooving tool 3304. This embodiment 3304 has a PDC layer 3305 fixed to a tungsten carbide substrate 3306. A gullet 3307 is provided on the top o the PDC layer 3305. An optional mounting hole 3308 is provided in the tool 3304.

Figure 33b shows the tool 3304 brazed to a tungsten carbide tool 3309 with the preferred tungsten carbide layers 3310, 3311 with the PDC layer 3312 brazed thereto.

Figure 33c shows an alternative tool 3318 with a concave gullet 3315 imposed in a PDC layer, which is brazed or otherwise fixed to a tungsten carbide layer.

Figure 33d shows another alternative tool 3319 with the gullet 3317 not extending to the edge of the tool 3319. This embodiment 3319 is shown as composed of a single PDC material.

Figure 34 shows a perspective view of another square embodiment 3400 of the invention. This embodiment 3400 is shown as a solid polycrystalline diamond tool 3401, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A plurality of protuberances 3402a-d are generally located near the corners of the top surface 3402. A center clamping hole 3404 is provided.

Figure 35 shows a perspective view of another square embodiment 3500 of the invention. This embodiment 3500 is shown as a solid polycrystalline diamond tool 3501, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A top surface 3503 with a cutting edge 3505 is provided atop a machined edge 3502. A center clamping hole 3504 is provided.

Figure 36 shows a perspective view of another square embodiment 3600 of the invention. This embodiment 3600 is shown as a solid polycrystalline diamond tool 3601, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A recess 3603 is provided in the top surface 3602 of the tool 3600. A center clamping hole 3604 is provided.

Figure 37 shows a perspective view of another square embodiment 3700 of the invention. This embodiment 3700 is shown as a solid polycrystalline diamond tool 3701, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A machined top surface 3703 is provided with a center-clamping hole 3704.

Figure 38 shows a perspective view of another square embodiment 3800 of the invention. This embodiment 3800 is shown as a solid polycrystalline diamond tool 3801, although in alternative embodiments, a tungsten carbide substrate can be bonded to the bottom of the shown PDC region. A plurality of triangular protuberances 3802a-d extend from an elevated ridge 3804, within which is a center clamping hole 3805 are provided.

Figure 39a is a side view of one preferred insert type of the invention. This embodiment 3901 is single sided 3902 with two recesses 3903a,b.

Figure 39b is a side view of a second preferred insert type of the invention. This embodiment 3904 is double sided 3905, 3907, each with two recesses 3906a,b and 3908a,b.

Figure 39c is a side view of a third preferred insert type of the invention. This embodiment 3909 is single sided 3910 with two recesses 3911a,b and a hole 3912.

Figure 39d is a side view of a fourth preferred insert type of the invention. This embodiment 3913 is double sided 3914, 3917, each with two recesses 3915a,b and 3918a,b and a hole 3916.

Figure 40a shows a top detail view of a flat 4002 corner tip 4001 of the invention.

Figure 40b shows a top detail view of a radius 4004 corner tip 4003 of the invention.

Figure 40c shows a top detail view of a wiper radius 4006 corner tip 4005 of the invention.

Figure 40d shows a top detail view of a sharp 4008 corner tip 4007 of the invention.

Figure 40e shows a top detail view of a two-facet flat 4010 corner tip 4009 of the invention.

Figures 41a-u are side views of various alternative gullet designs, which can be incorporated in this invention. A negative rounded or radius gullet 4101 is shown in figure 41a. A negative equilateral triangle gullet 4102 is shown in figure 41b. A negative angled gullet 4103 is shown in figure 41c. A negative complex radius gullet 4104 is shown in figure 41d. A negative square or rectangular gullet 4105 is shown in figure 41e. A negative mixed geometry gullet 4106 is shown in figure 41f. A positive rounded or radius gullet 4107 is shown in figure 41g. A positive equilateral triangle gullet 4108 is shown in figure 41h. A positive angled gullet 4109 is shown in figure 41i. A positive complex radius gullet 4110 is shown in figure 41j. A positive square or rectangular gullet 4111 is shown in figure 41k. A positive mixed geometry gullet 4112 is shown in figure 41L. A negative tri-level gullet 4113 is shown in figure 41m. A negative bi-level gullet 4114 is shown in figure 41n. A positive double rounded gullet 4115 is shown in figure 41o. A positive double level gullet 4116 is shown in figure 41p. A negative double rounded gullet 4117 is shown in figure 41q. A first combination positive-negative gullet 4118 is shown in figure 41r. A second combination positive-negative gullet 4119 is shown in figure 41s. A third combination positive-negative gullet 4120 is shown in figure 41t.

Figures 42a-e are side view of various alternative edge details of this invention. A first edge 4201 is shown in figure 42a having a square corner 4202 and a

single gullet 4203. A second edge 4204 is shown in figure 42b having an angled 4205 corner and a single gullet 4206. A third edge 4207 is shown in figure 42c having a reverse angled 4208 corner and a single gullet 4209, with a protuberance 4216. A fourth edge 4210 is shown in figure 42d having an angled side 4211 and a single gullet 4212. A fifth edge 4213 is shown in figure 42e having a squared side 4214 and a single gullet 4215. A sixth edge 4217 is shown in figure 42f having a single gullet 4219 which meet the side of the edge 4217 at a point 4219. A seventh edge embodiment 4220 is shown in figure 42g having an angled edge 4221 with a single gullet 4222. A eight edge embodiment 4223 is shown in figure 42h having an angled edge 4224 which meets the single gullet 4229 at a point 4225. A ninth edge embodiment 4227 is shown in figure 42i having the single gullet 4229 meeting the edge 4227 at an extended point 4228. A tenth edge embodiment 4230 is shown in figure 42j having an angled edge which meets the single gullet 4232 at an alternative extended point 4231. An eleventh edge embodiment 4233 is shown in figure 42k having an angled edge which meets the single gullet 4235 at a second alternative extended point 4234.

Figure 43a is a side view of an alternative configuration 4300 of this invention having PDC regions 4301a,b on each side of the tungsten carbide region 4302. A hole 4304 is provided in the carbide region 4302. Gullets 4303a-d are provided in the PDC regions 4301a,b.

Figure 43b is a side view of a second alternative configuration 4305 of this invention having PDC regions 4306, 4307 on the top and bottom surfaces of the tungsten carbide region 4309. Gullets 4308a-d are provided in the PDC regions.

Figure 44 is a side view showing an alternative 4400 use of spokes and gullet in this invention. The spokes 4403, 4404 can follow the gullet profile 4405, 4406 from the center land 4402, or they 4403, 4404 can follow unique paths.

Figures 45a-c show side view of alternative rake angle variations in this invention. A rake angle 4504 of approximately 90° relative to the length of the tool 4501 is shown in figure 45a. A rake angle 4505 of less than 90° relative to the length of the tool 4502 is shown in figure 45b. A rake angle 4506 of greater than 90° relative to the length of the tool 4503 is shown in figure 45c.

Figures 46a-l show side and top view of various alternative triangular chip breaker embodiments of this invention. Figure 46a shows the side view of a triangle wedge 4601. Figure 46b shows the top view of the triangle wedge 4601. Figure 46c shows the side view of the rounded top oval 4602. Figure 46d shows the top view of the rounded top oval 4602. Figure 46e shows the side view of the rounded top triangle 4603. Figure 46f shows the top view of the rounded top triangle 4603. Figure 46g shows the side view of the double triangle 4604. Figure 46h shows the top view of the double triangle 4604. Figure 46i shows the side view of the back-to-back wedge 4605. Figure 46j shows the top view of the back-to-back wedge 4605. Figure 46k shows a side view of the raised up ridge inside a gullet parameter 4606. Figure 46L shows the top view of the raised up ridge inside a gullet parameter 4606.

Figure 47 shows an alternative embodiment of the chip breakers 4705a,b,c,d brazed to a tungsten carbide tool 4700, which is shown with an optional mounting hole 4706. The chip breakers 4705a,b,c,d,e,f,g,h have a top surface

4704a,b,c,d,e,f,g,h a PDC layer 4701a,b,c,d,e,f,g,h and a tungsten carbide substrate 4702a,b,c,d.

Figure 48 shows another alternative embodiment of the chip breaker 4800, having gullets 4803a,b,c,d. A PDC layer 4801 is brazed to a first tungsten carbide layer 4804, which in turn is fixed to a second tungsten carbide layer 4802.

The embodiments of this invention described herein are but examples of the envisioned potential embodiments of this invention and are provided to fully describe and enable the best mode of the invention known to the inventors. These embodiments should be considered in all respects only as illustrative and not as restrictive. The scope of this invention is described by the appended claims and the equitable equivalents thereof.

Claims

We claim:

1. A chip breaker device, comprising a polycrystalline diamond structure, having a top surface, a gullet and a corner.

2. A chip breaker device, as recited in claim 1, wherein said structure is a generally rectangular shape.

3. A chip breaker device, as recited in claim 1, wherein said structure is a generally cylindrical shape.

4. A chip breaker device, as recited in claim 1, wherein said structure is a generally triangular shape.

5. A chip breaker device, as recited in claim 1, further comprising a first edge.

6. A chip breaker device, as recited in claim 1, further comprising a top plane surface.

7. A chip breaker device, as recited in claim 1, wherein said gullet is a positive convex gullet.

8. A chip breaker device, as recited in claim 1, wherein said gullet is a negative concave gullet.

9. A chip breaker device, as recited in claim 1, further comprising a chip splitter on said top surface of said structure.

10. A chip breaker device, as recited in claim 1, wherein said corner is selected from the group consisting of flat, radius, wiper radius, sharp and two facet flats.

11. A chip breaker device, as recited in claim 1, wherein said gullet is continuous.

12. A chip breaker device, as recited in claim 1, wherein said gullet is discontinuous.

13. A chip breaker device, as recited in claim 1, further comprising a mounting hole.

14. A chip breaker device, as recited in claim 1, further comprising a plurality of spokes between a center land and a machined edge.

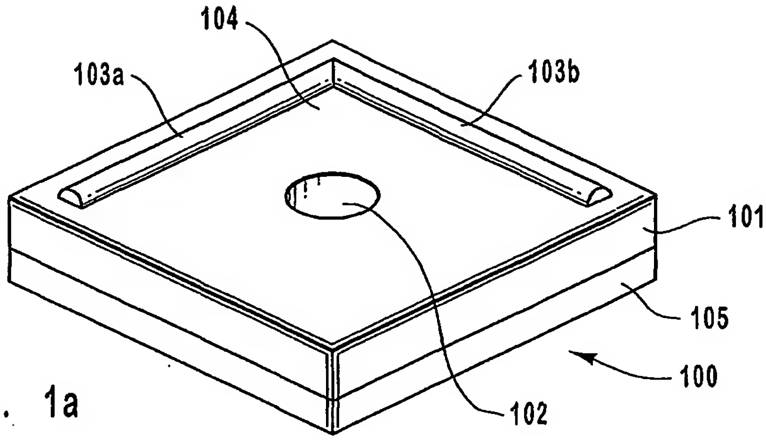

FIG. 1a

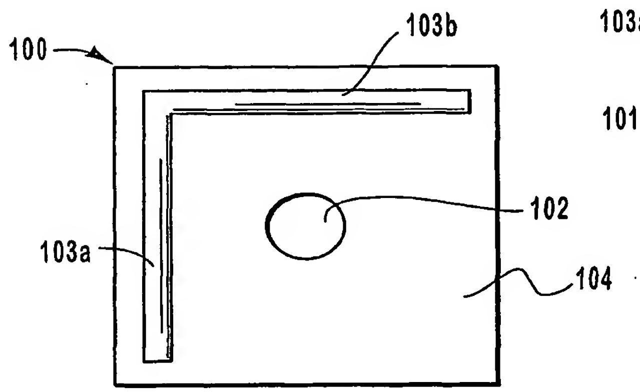

FIG. 1b

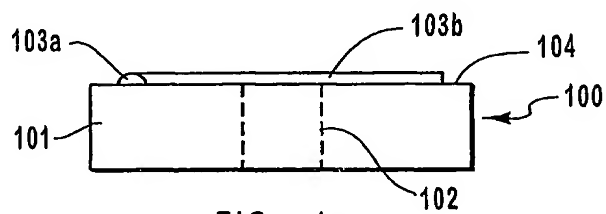

FIG. 1c

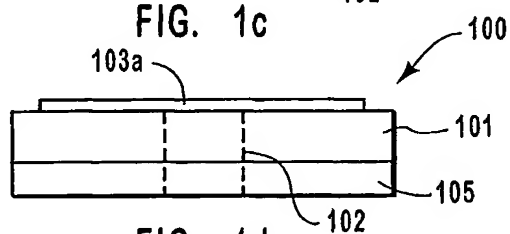

FIG. 1d

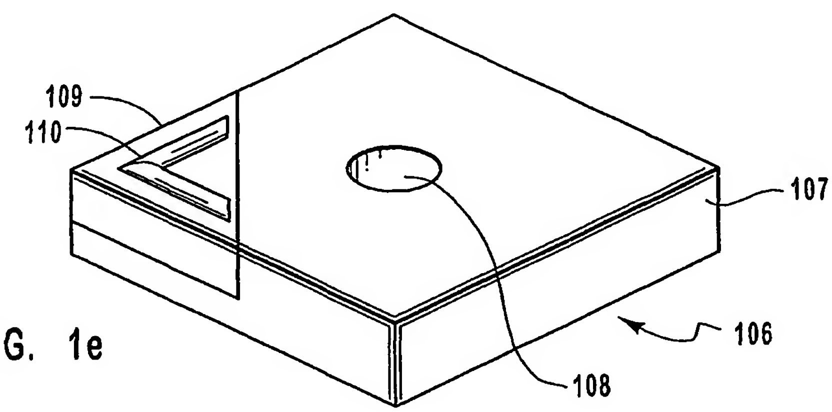

FIG. 1e

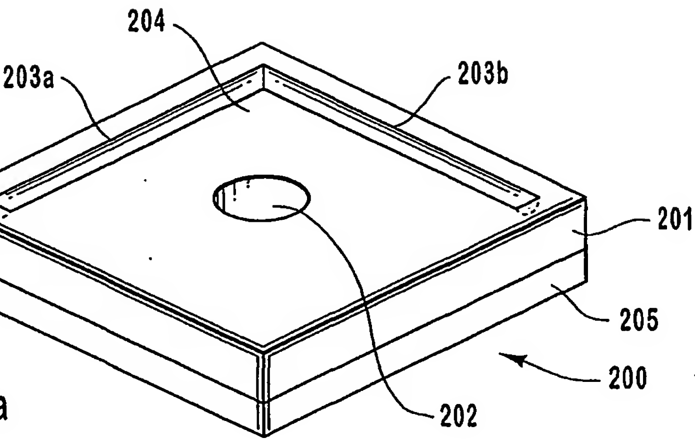

FIG. 2a

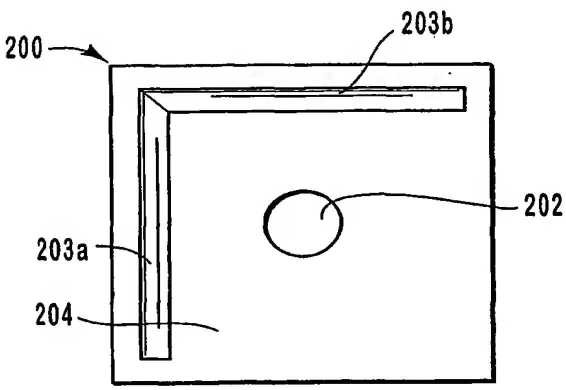

FIG. 2b

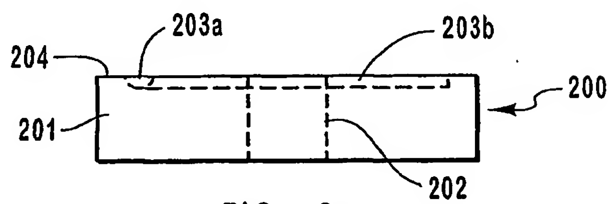

FIG. 2c

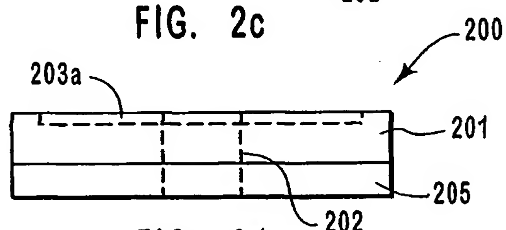

FIG. 2d

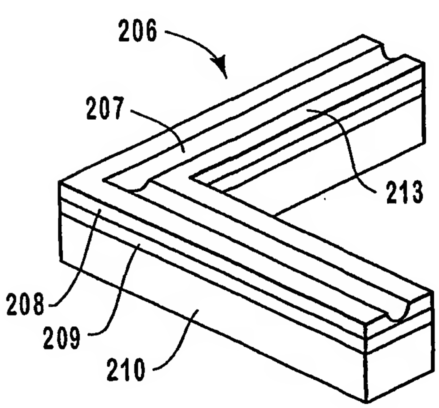

FIG. 2e

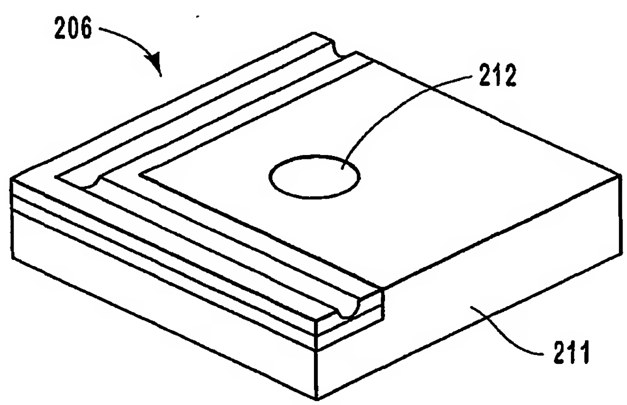

FIG. 2f

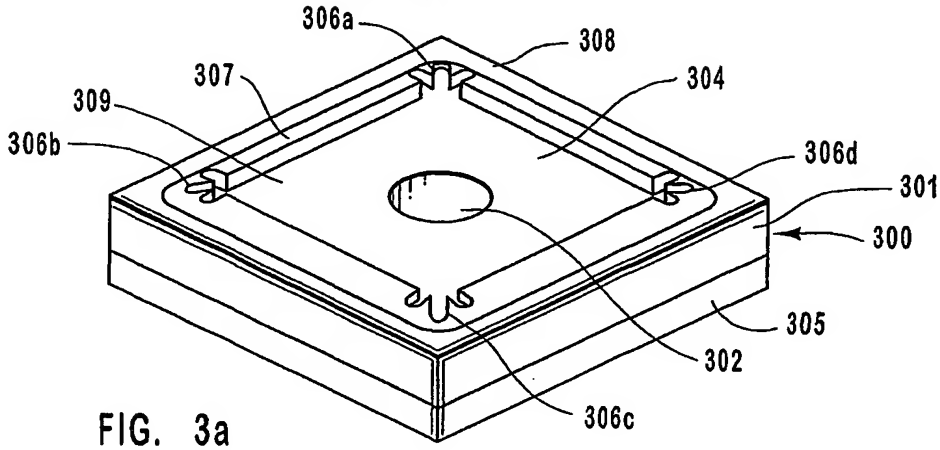

FIG. 3a

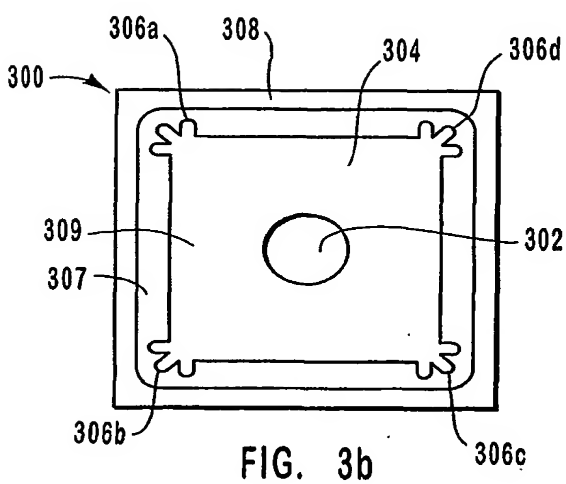

FIG. 3b

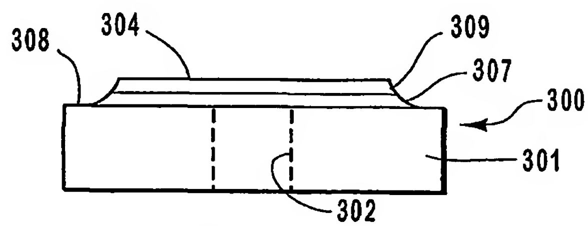

FIG. 3c

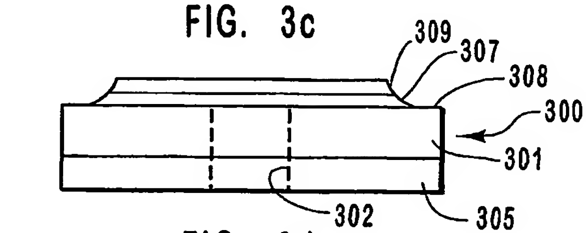

FIG. 3d

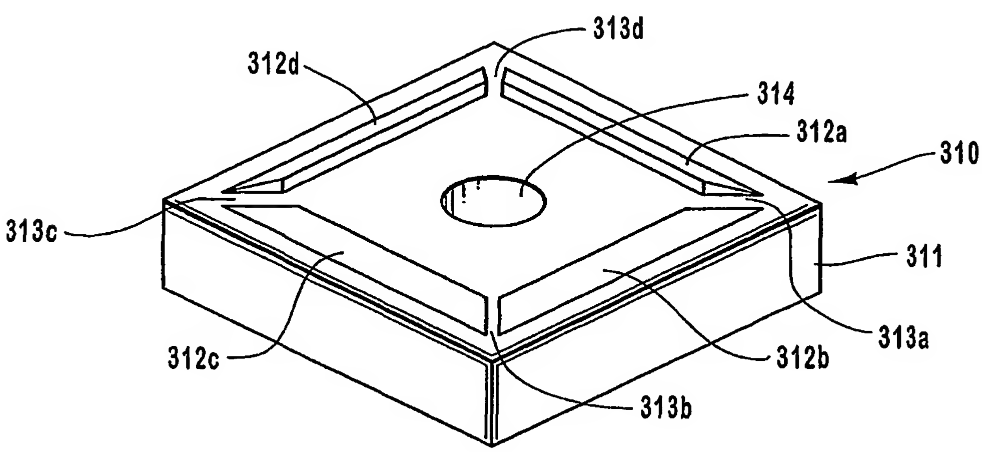

FIG. 3e

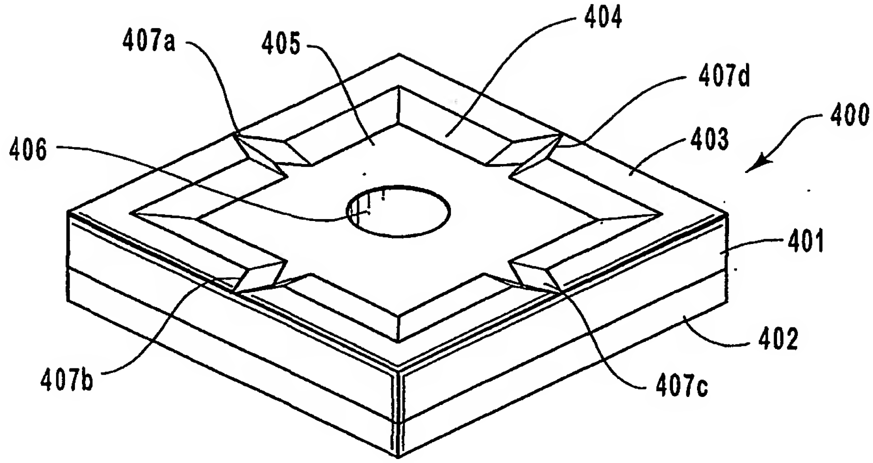

FIG. 4a

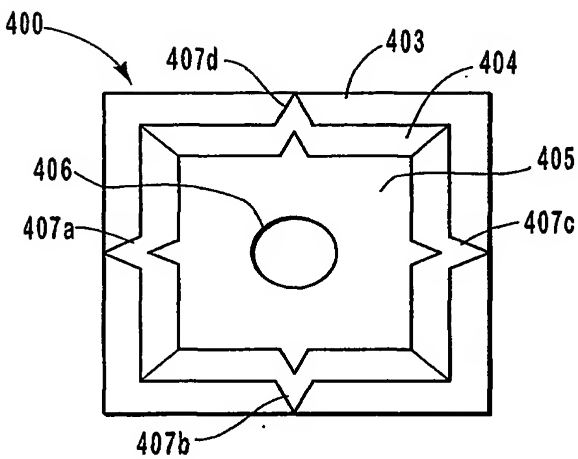

FIG. 4b

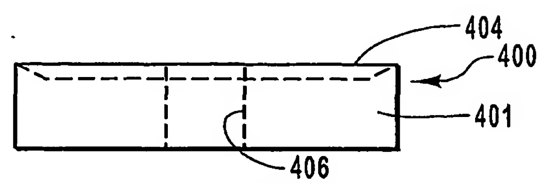

FIG. 4c

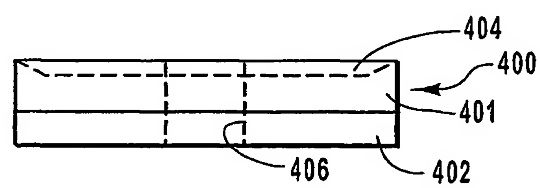

FIG. 4d

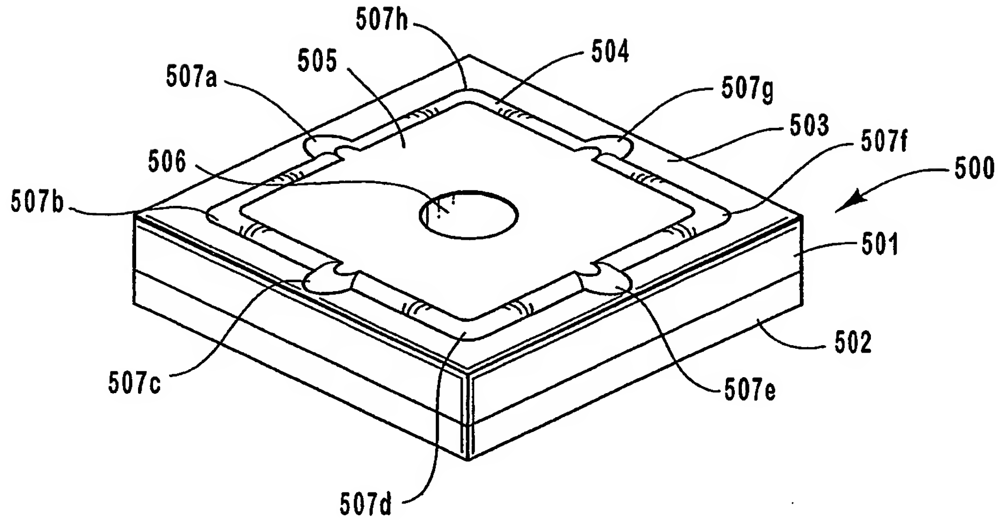

FIG. 5a

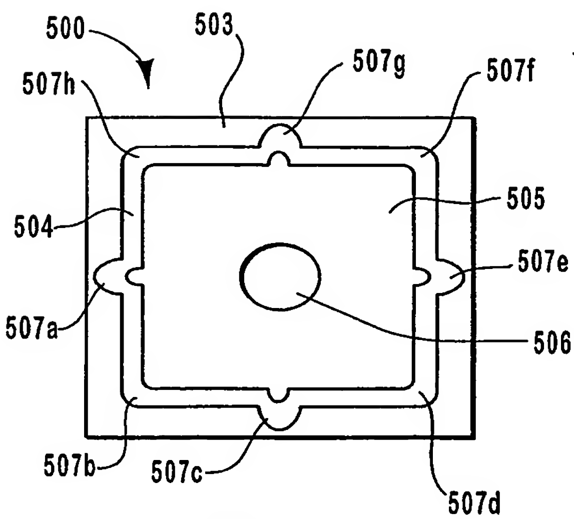

FIG. 5b

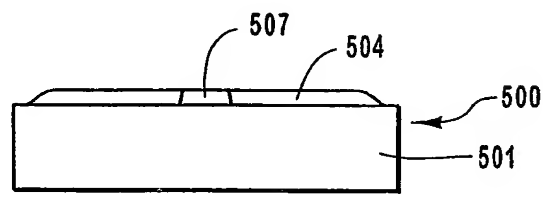

FIG. 5c

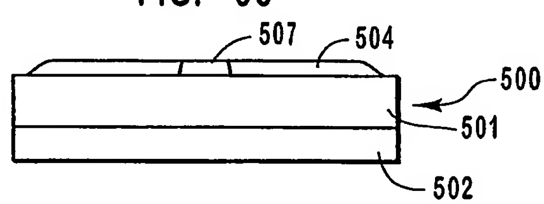

FIG. 5d

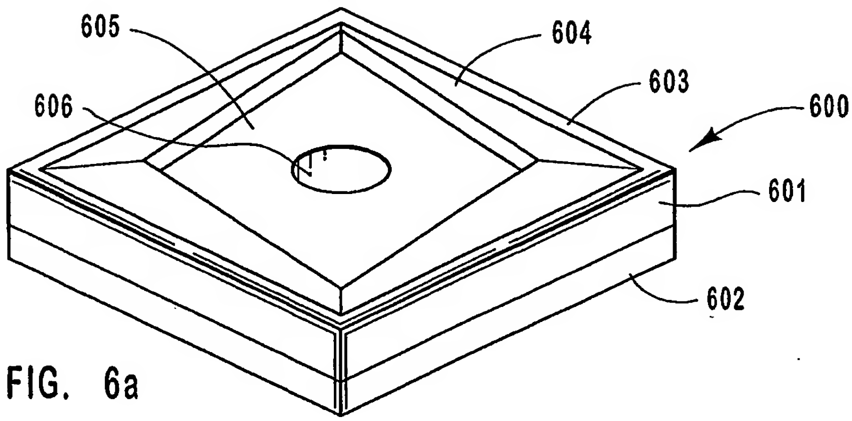

FIG. 6a

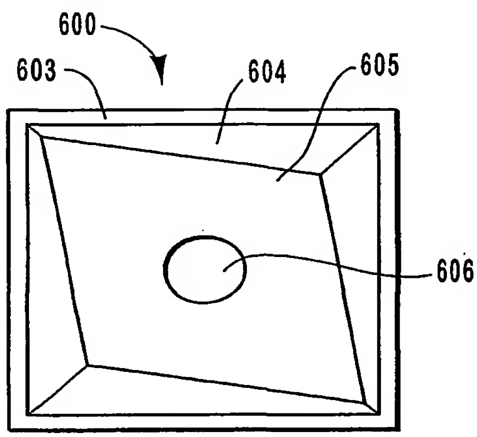

FIG. 6b

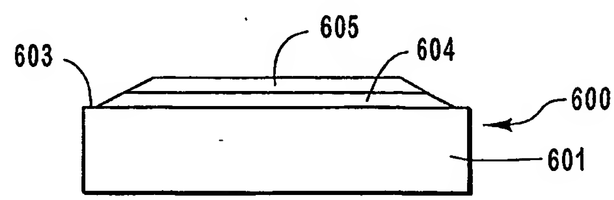

FIG. 6c

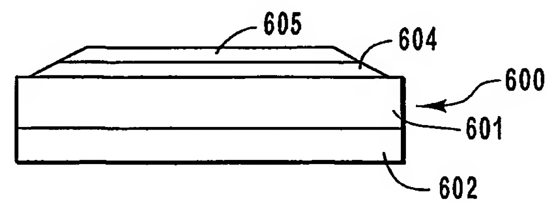

FIG. 6d

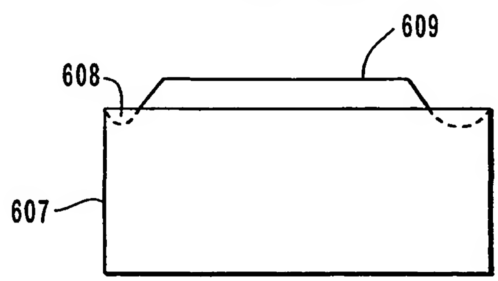

FIG. 6f

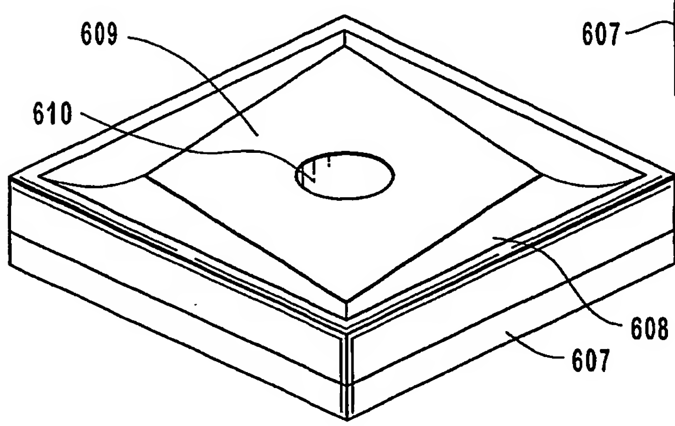

FIG. 6e

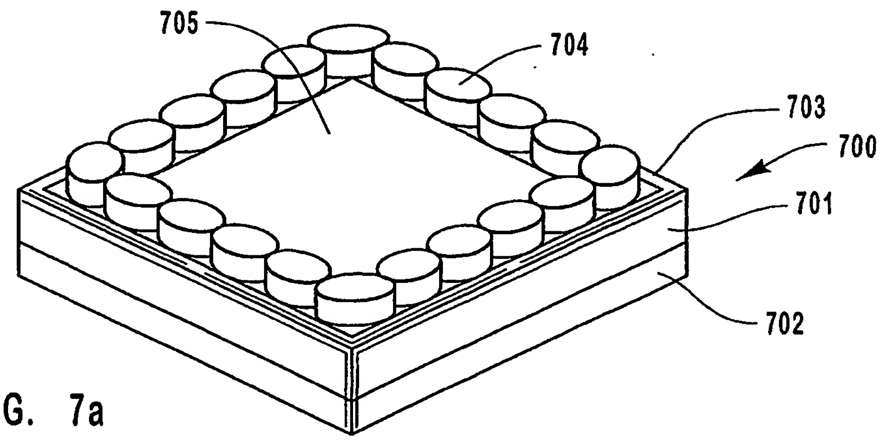

FIG. 7a

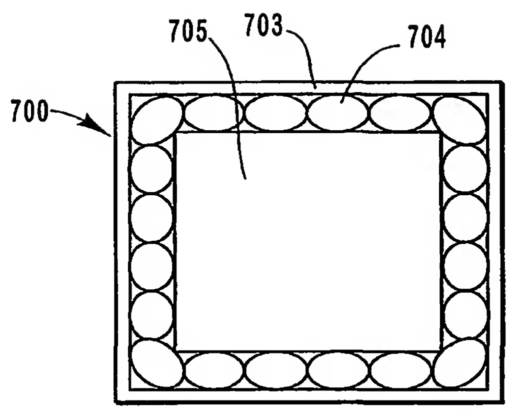

FIG. 7b

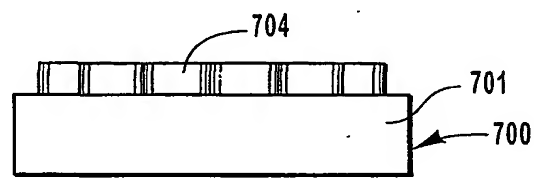

FIG. 7c

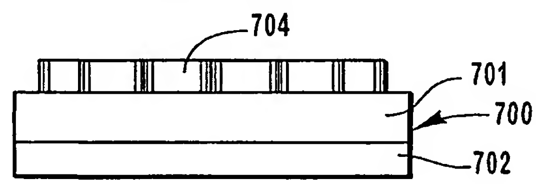

FIG. 7d

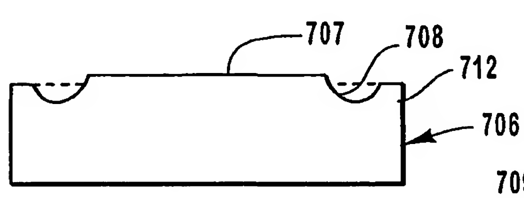

FIG. 7e

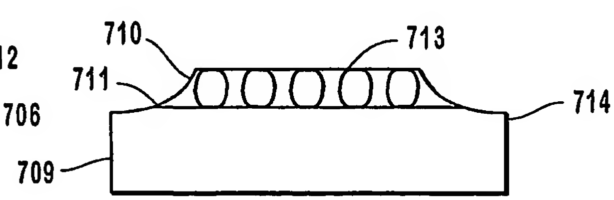

FIG. 7f

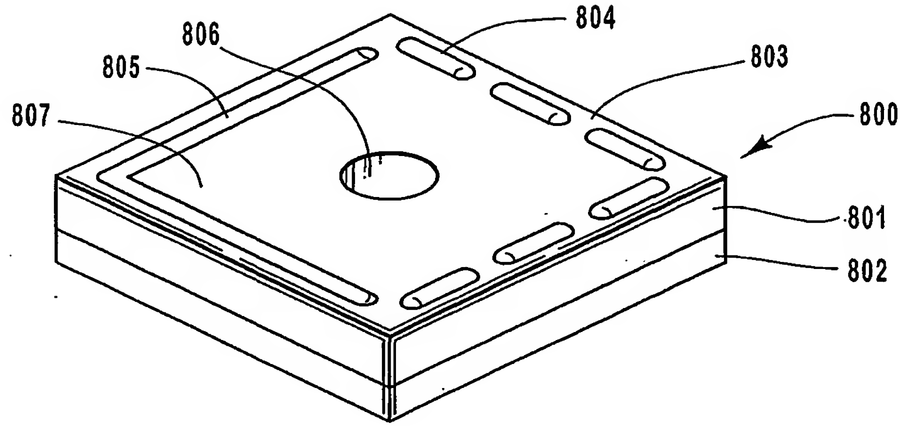

FIG. 8a

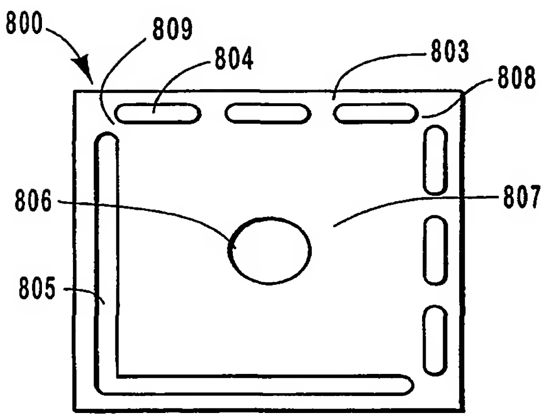

FIG. 8b

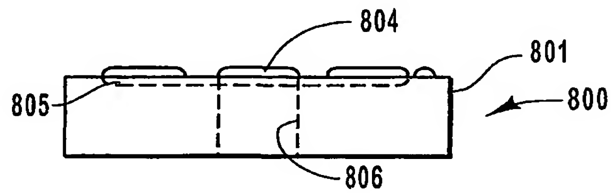

FIG. 8c

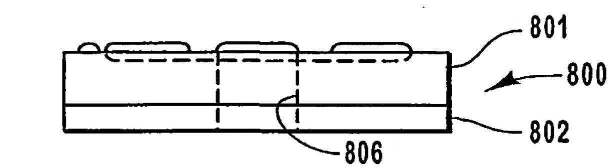

FIG. 8c

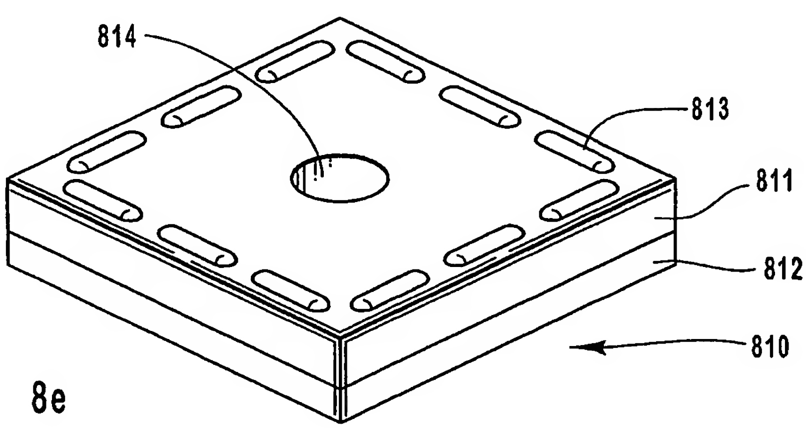

FIG. 8e

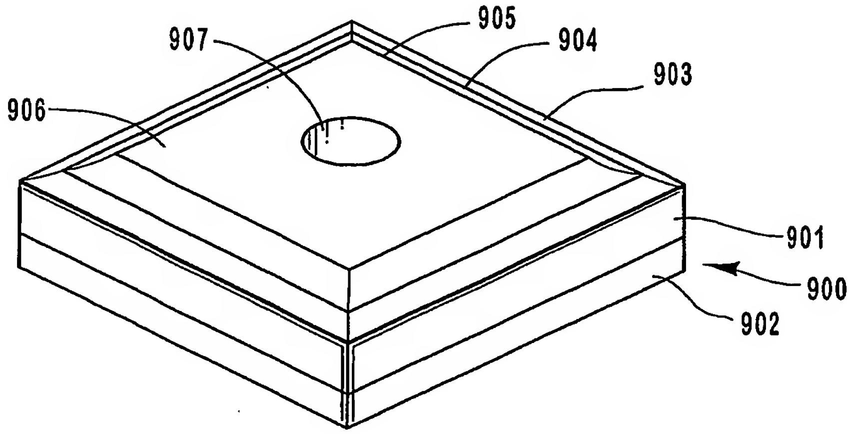

FIG. 9a

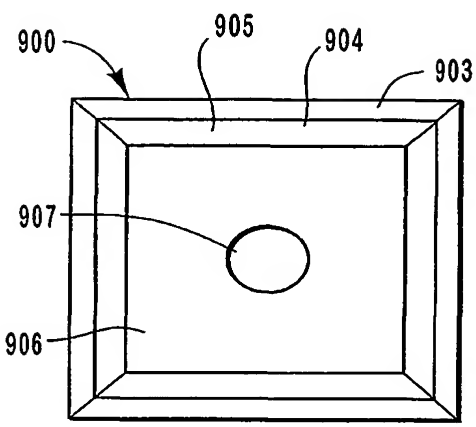

FIG. 9b

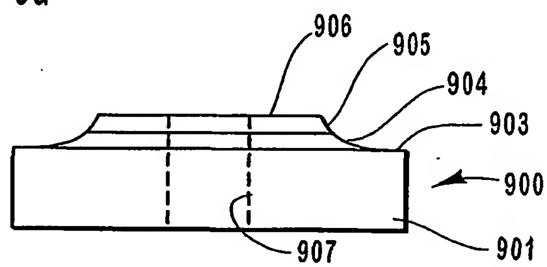

FIG. 9c

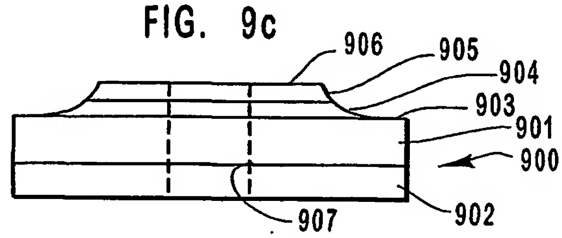

FIG. 9d

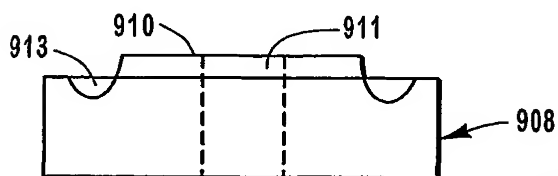

FIG. 9e

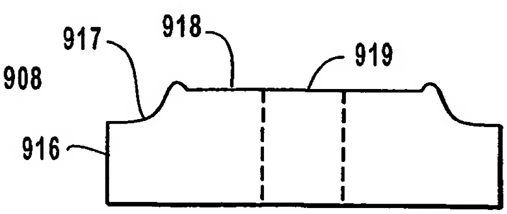

FIG. 9g

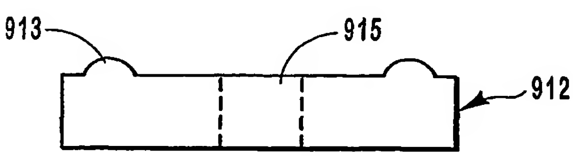

FIG. 9f

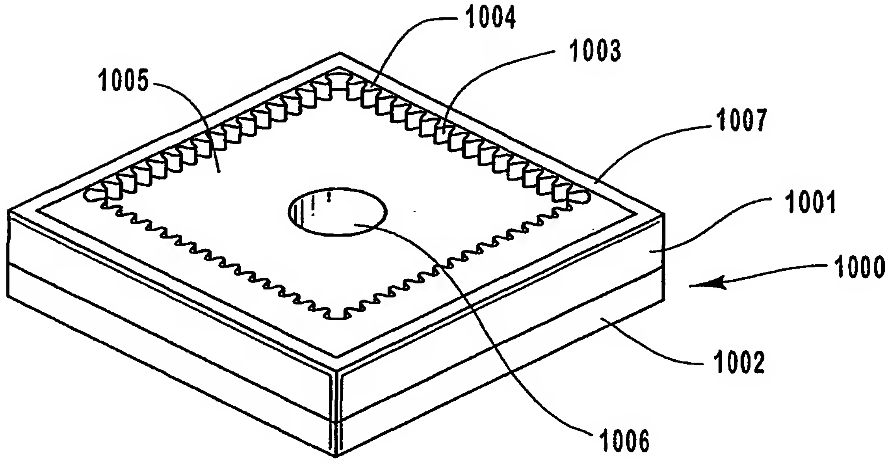

FIG. 10a

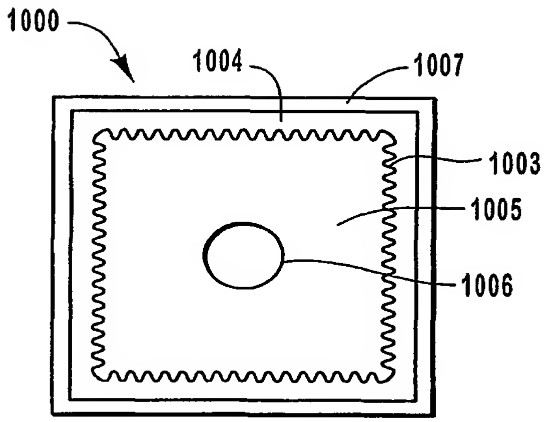

FIG. 10b

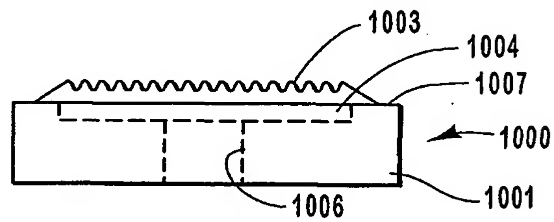

FIG. 10c

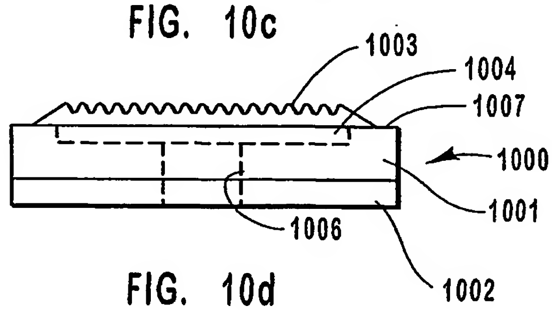

FIG. 10d

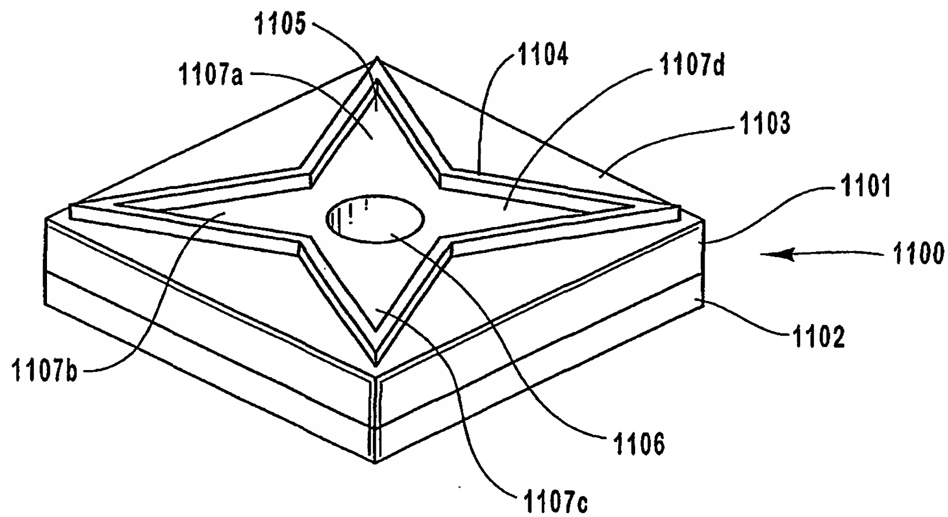

FIG. 11a

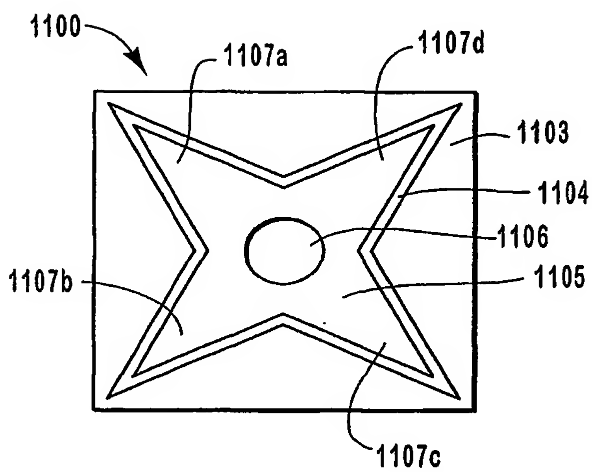

FIG. 11b

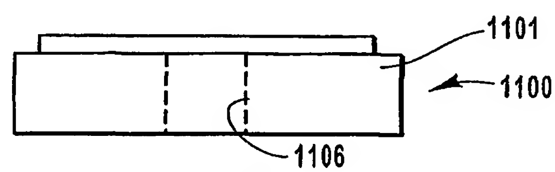

FIG. 11c

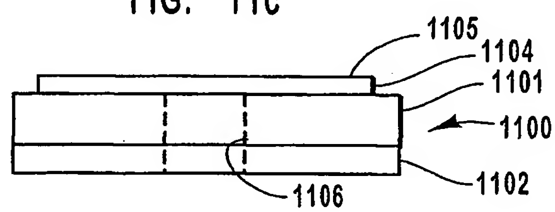

FIG. 11d

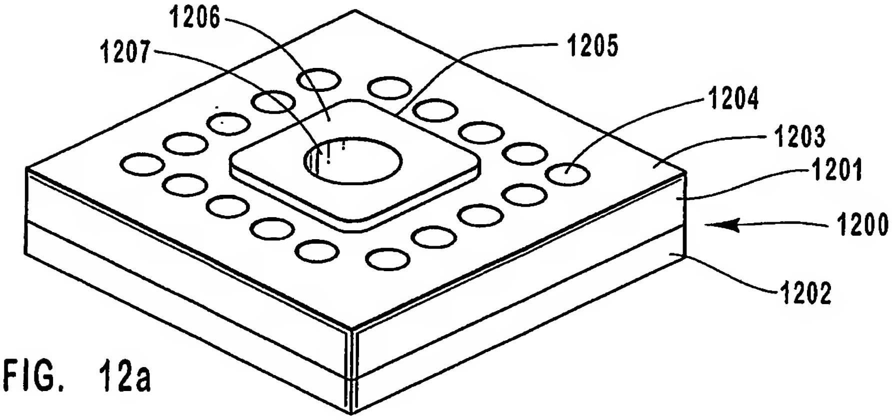

FIG. 12a

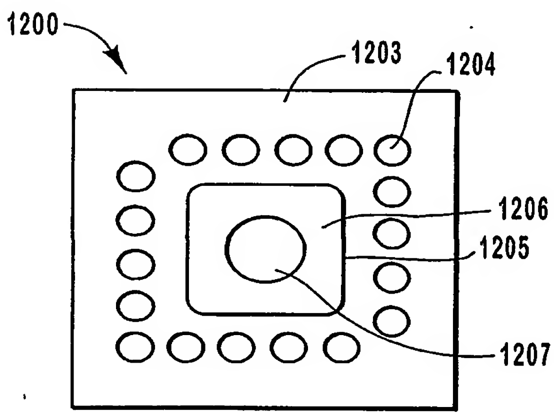

FIG. 12b

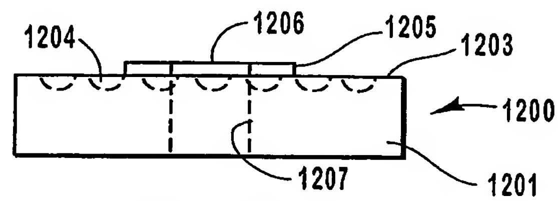

FIG. 12c

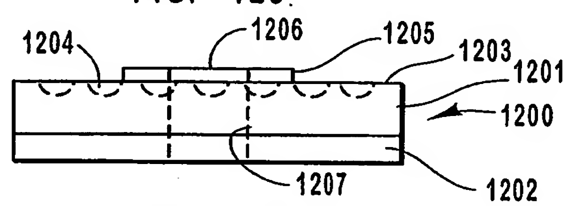

FIG. 12d

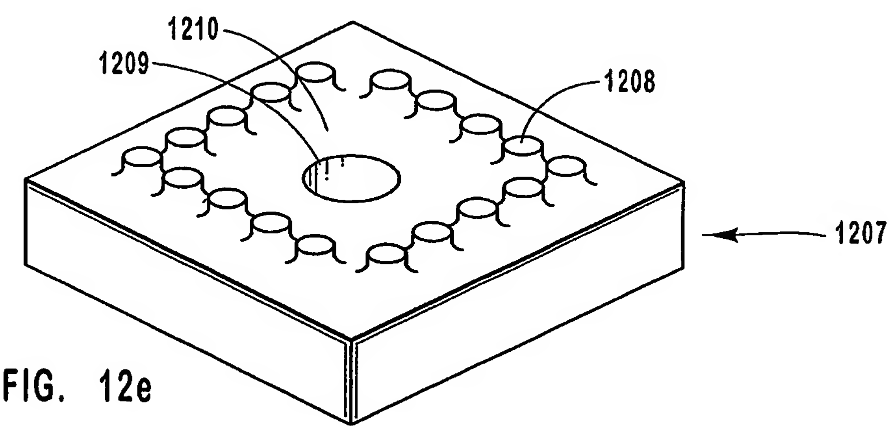

FIG. 12e

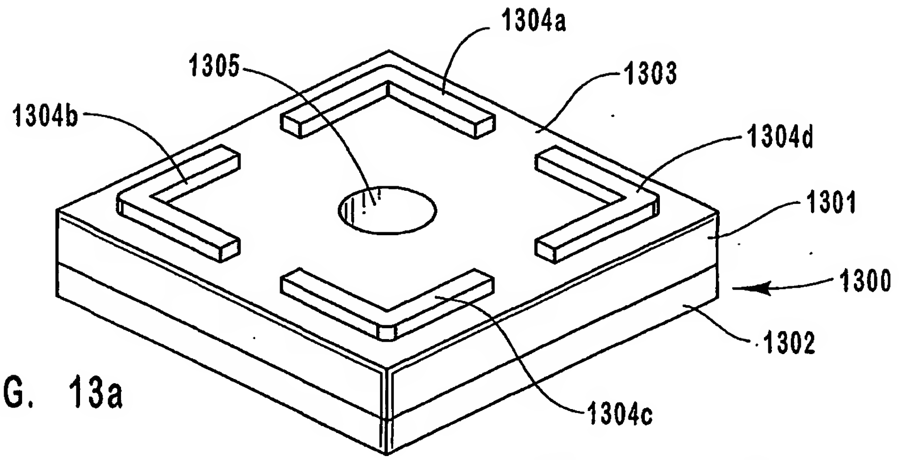

FIG. 13a

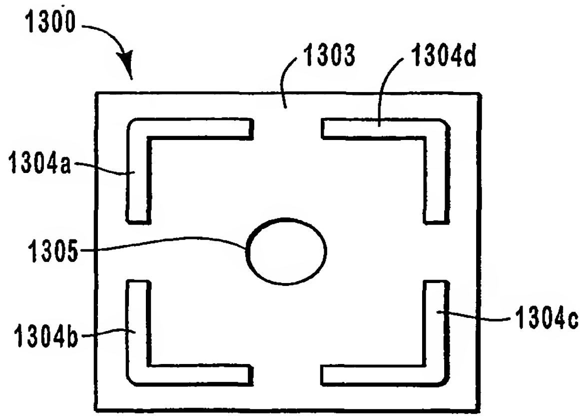

FIG. 13b

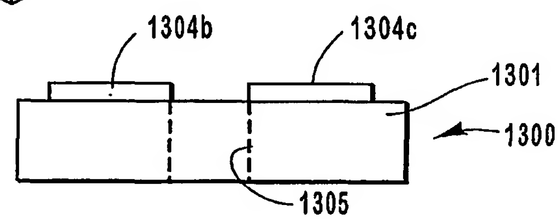

FIG. 13c

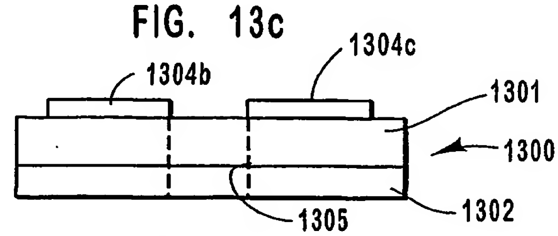

FIG. 13d

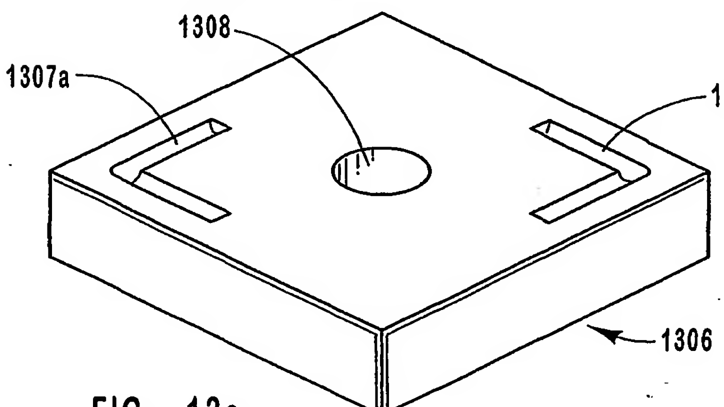

FIG. 13e

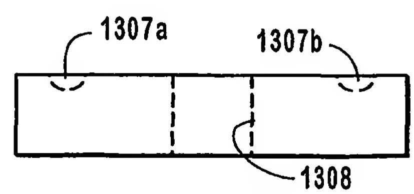

FIG. 13f

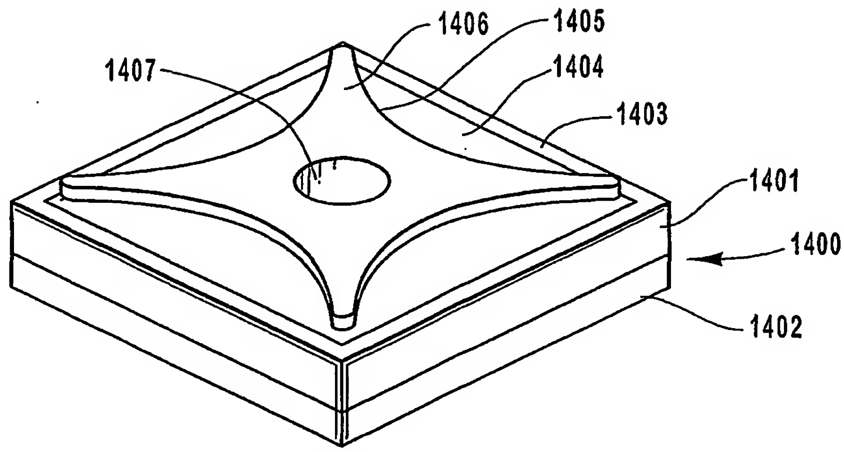

FIG. 14a

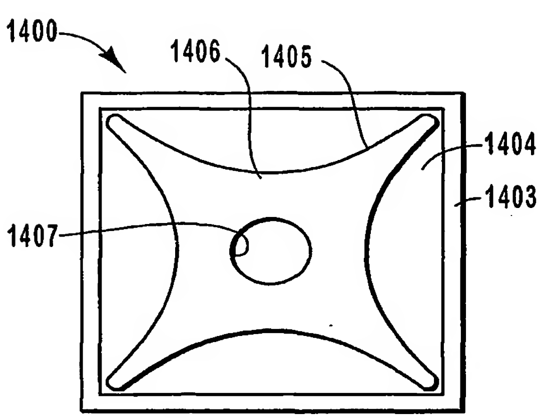

FIG. 14b

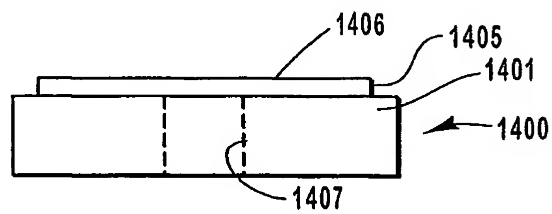

FIG. 14c

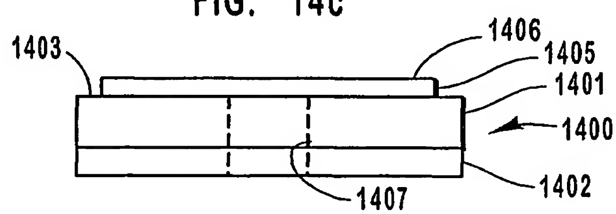

FIG. 14d

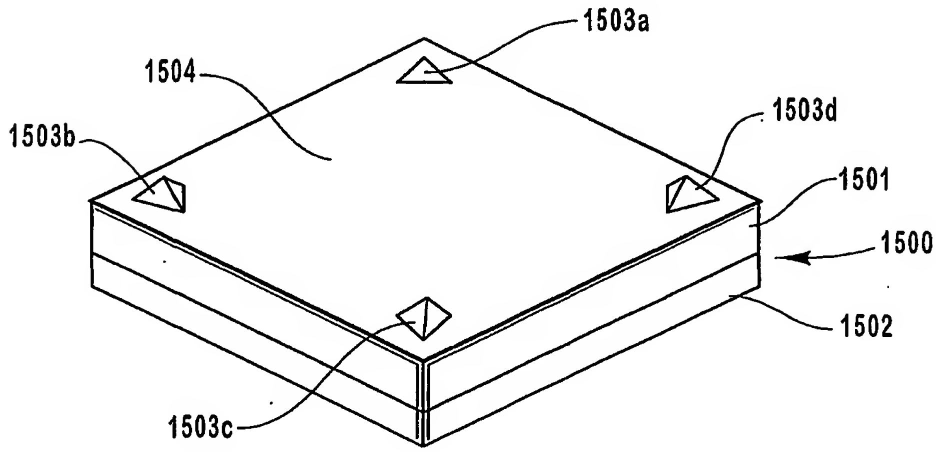

FIG. 15a

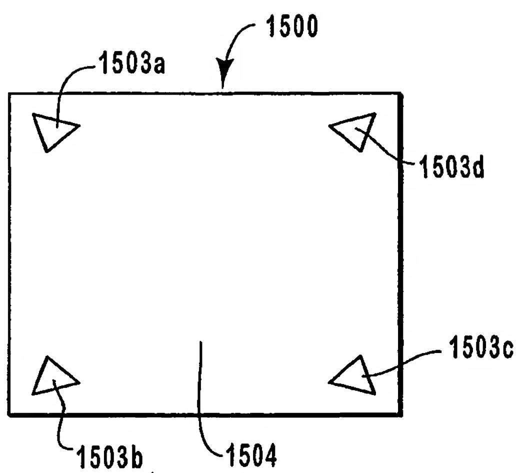

FIG. 15b

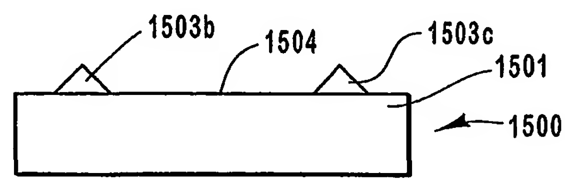

FIG. 15c

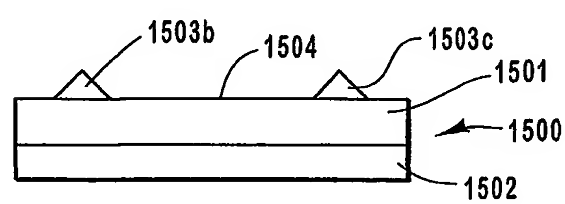

FIG. 15d

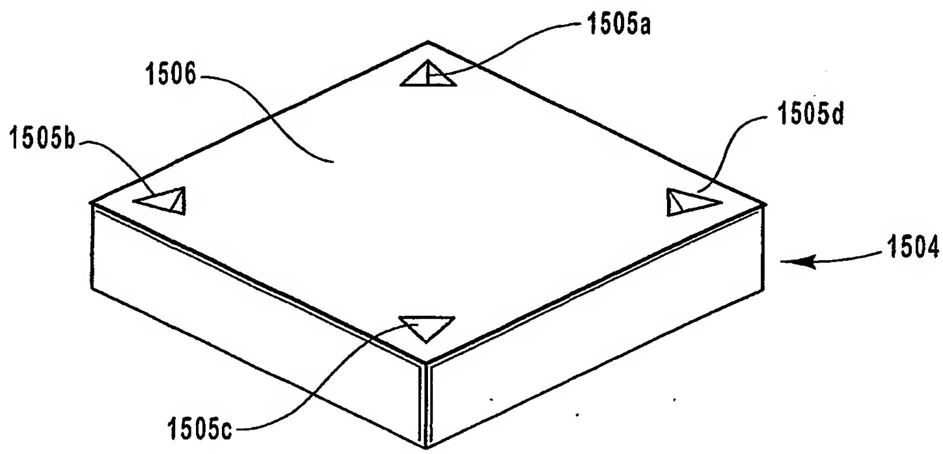

FIG. 15e

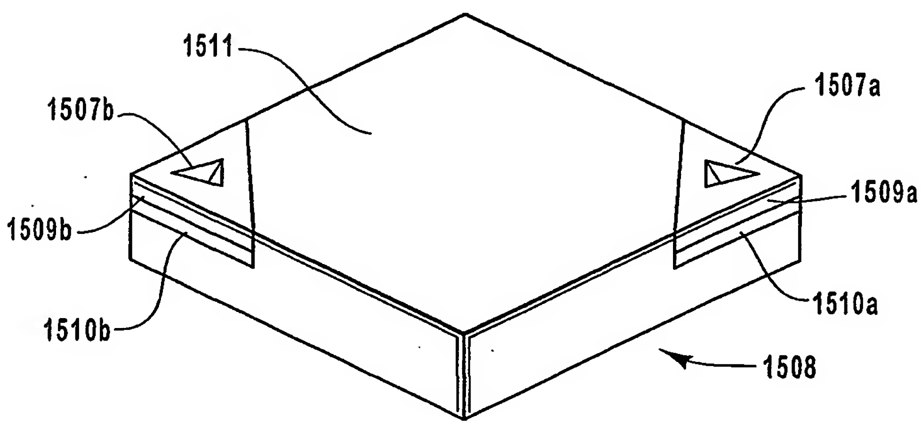

FIG. 15f

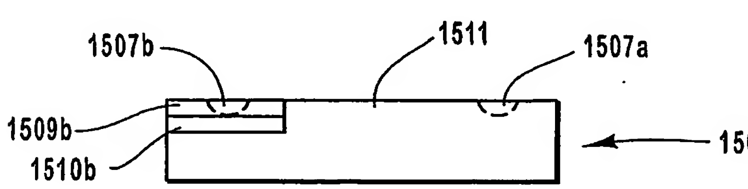

FIG. 15g

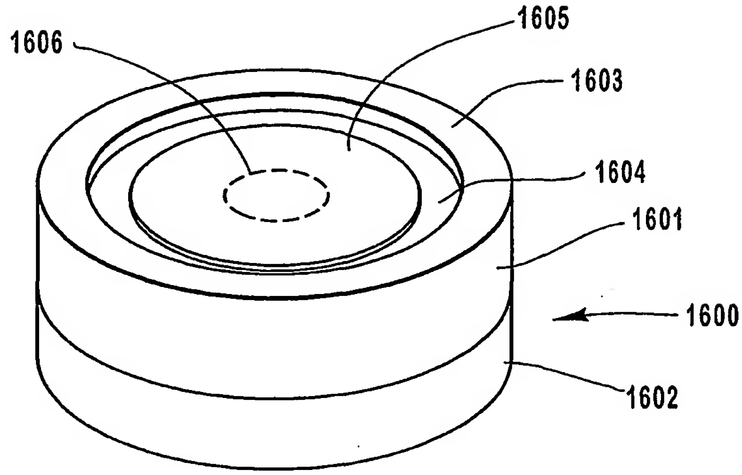

FIG. 16a

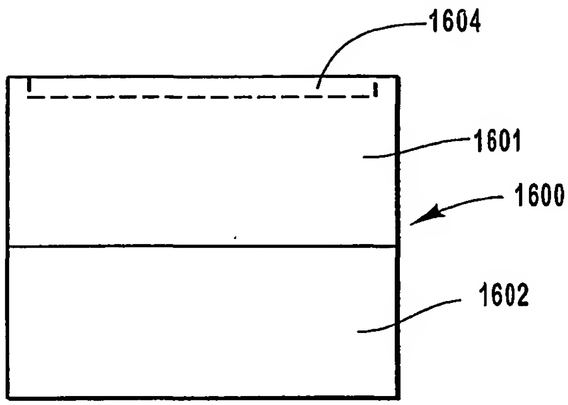

FIG. 16b

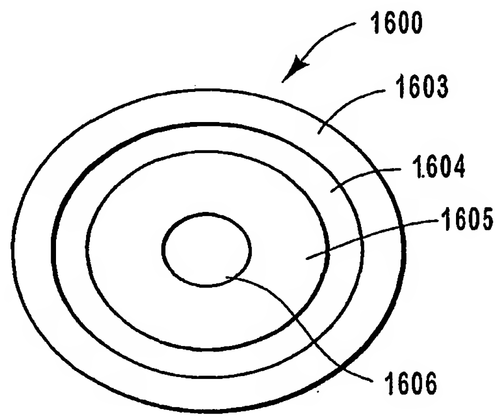

FIG. 16c

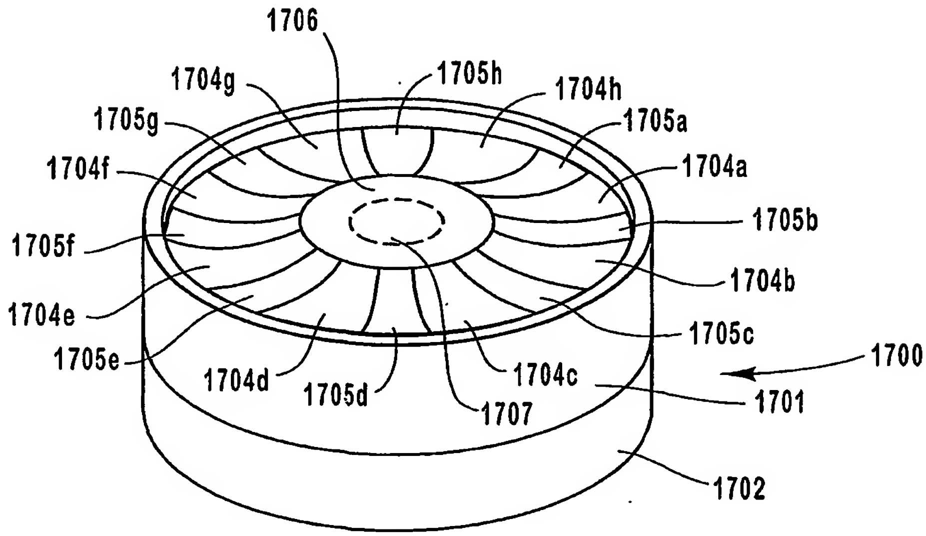

FIG. 17a

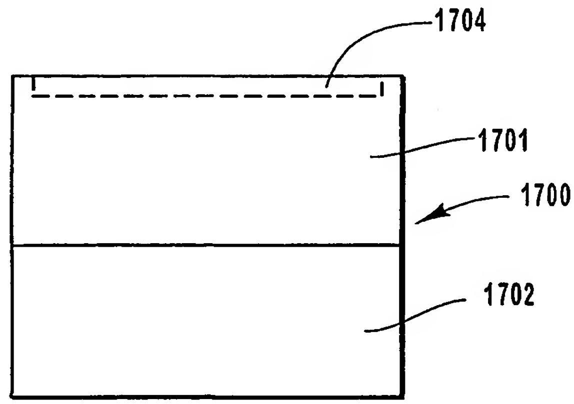

FIG. 17b

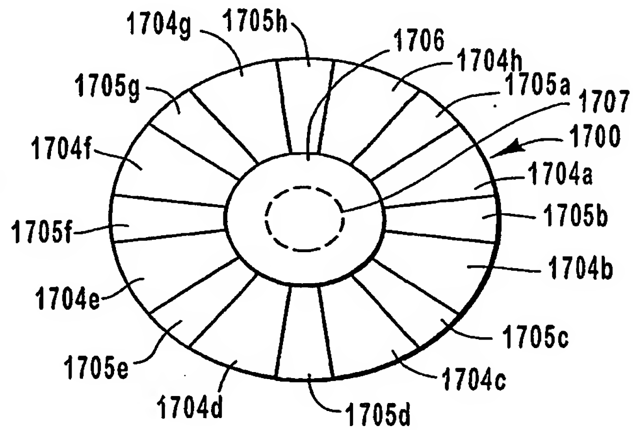

FIG. 17c

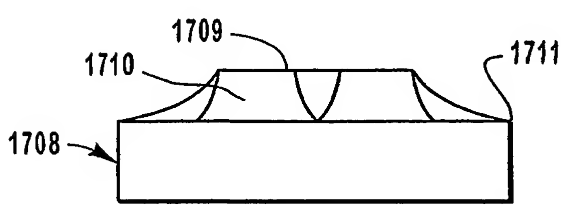

FIG. 17e

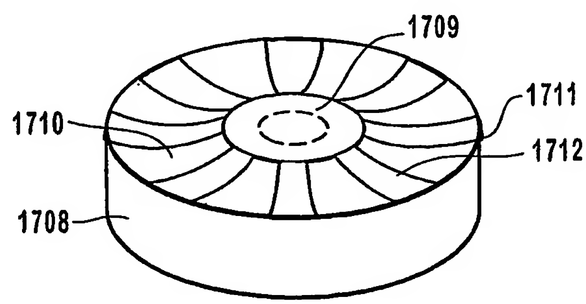

FIG. 17d

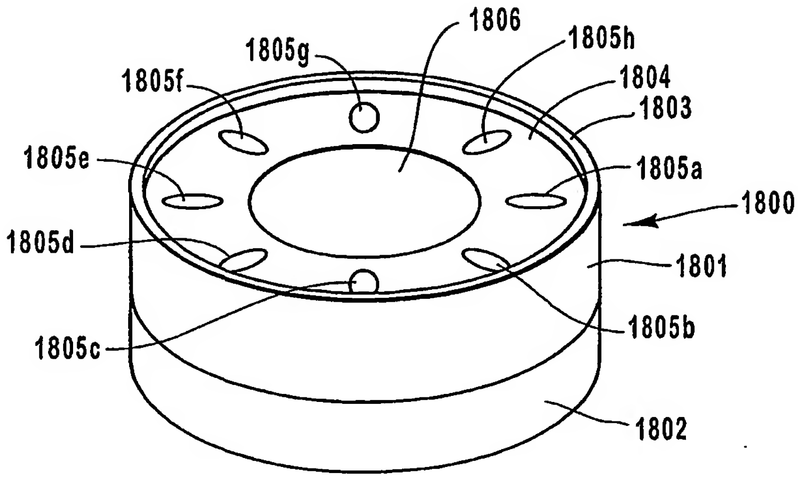

FIG. 18a

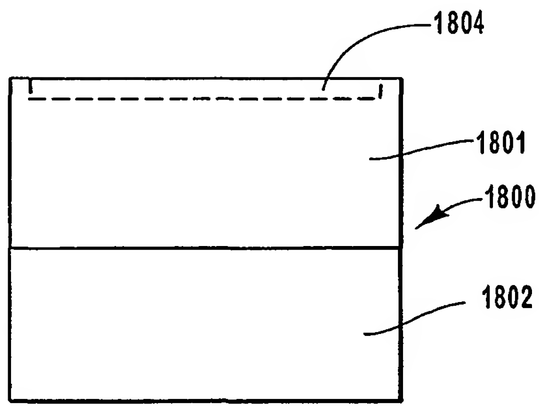

FIG. 18b

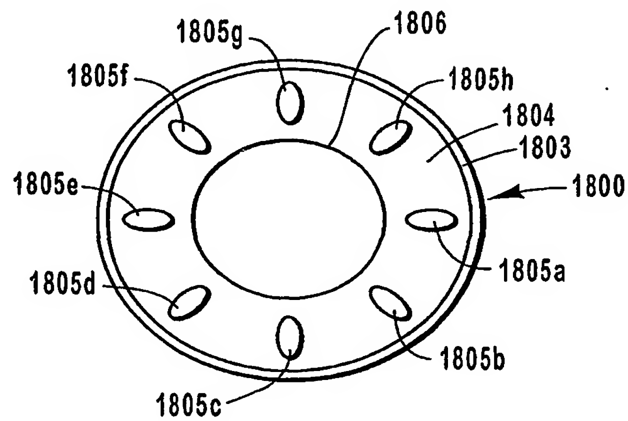

FIG. 18c

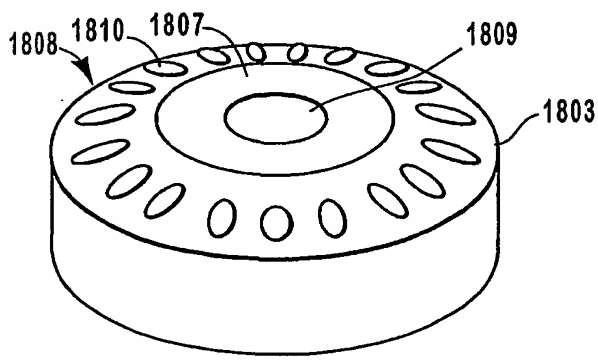

FIG. 18d

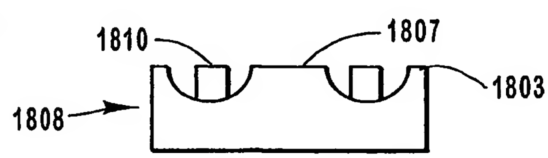

FIG. 18e

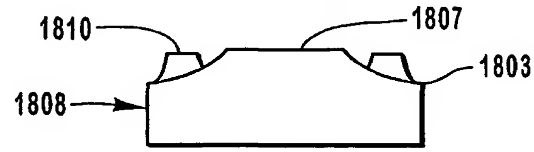

FIG. 18f

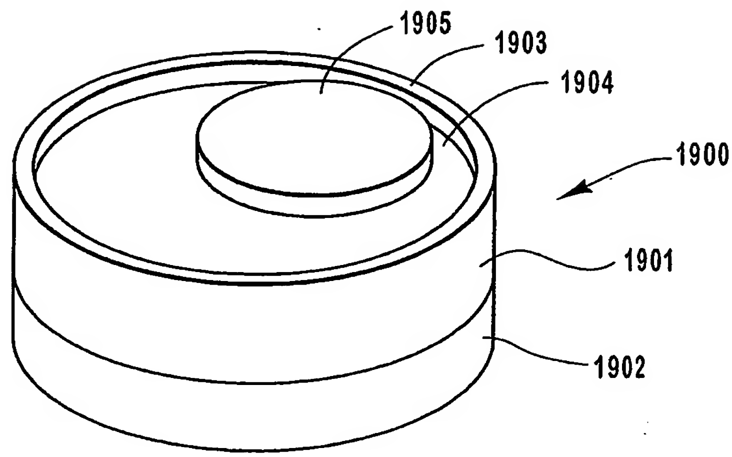

FIG. 19a

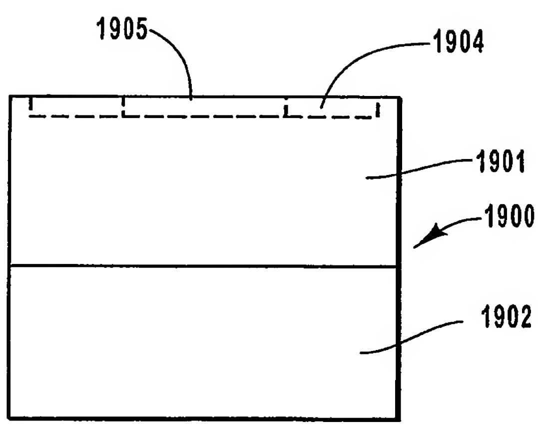

FIG. 19b

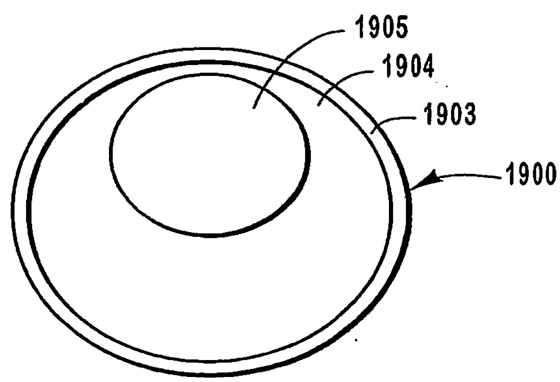

FIG. 19c

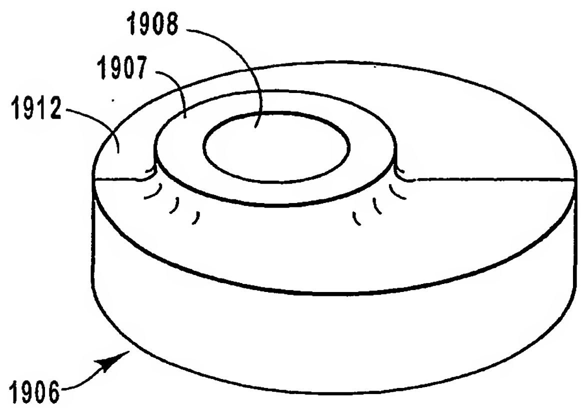

FIG. 19d

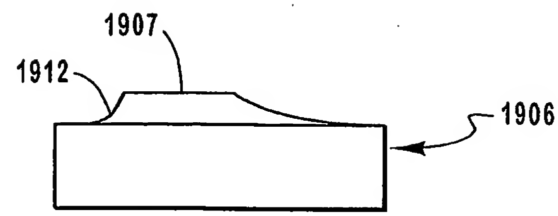

FIG. 19f

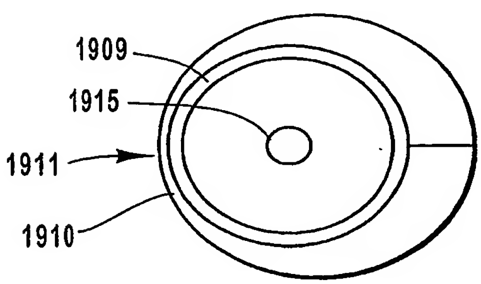

FIG. 19e

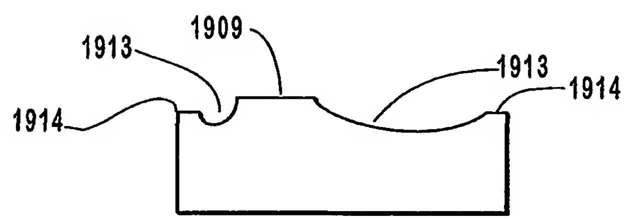

FIG. 19g

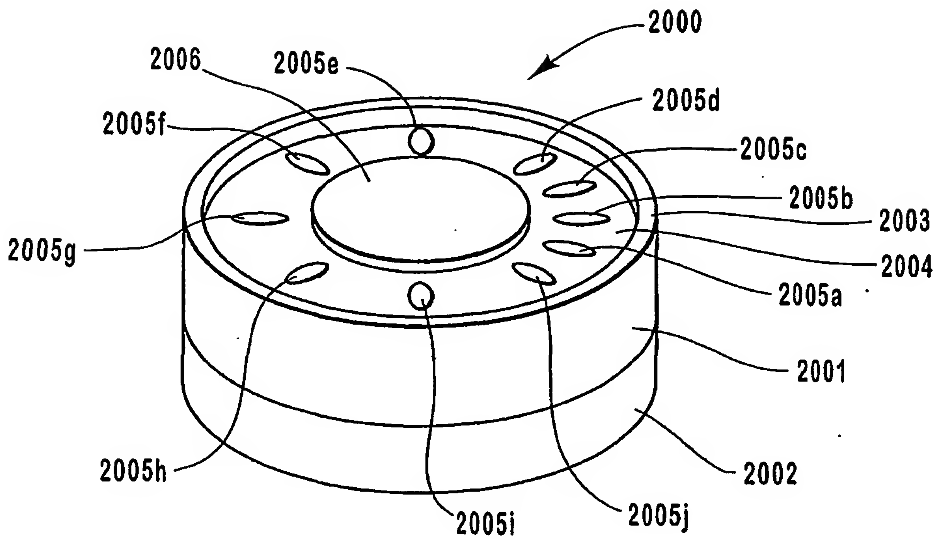

FIG. 20a

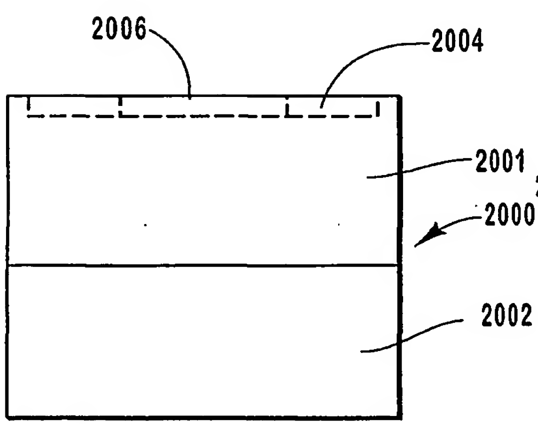

FIG. 20b

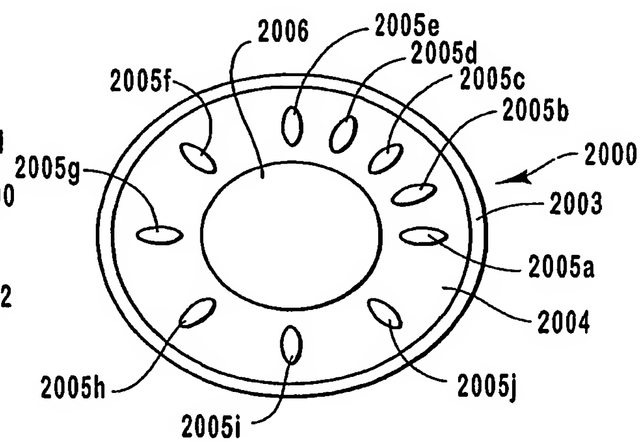

FIG. 20c

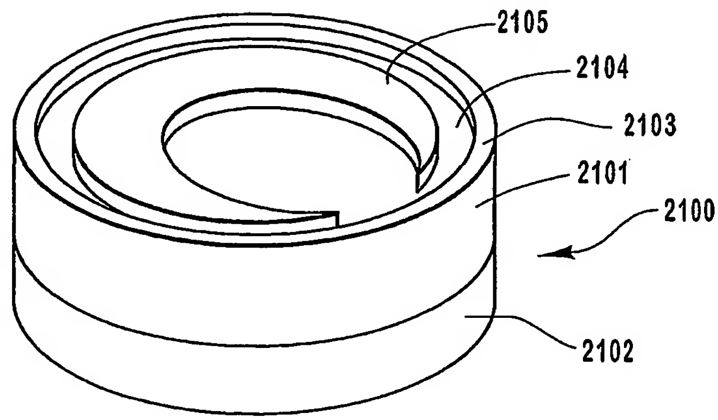

FIG. 21a

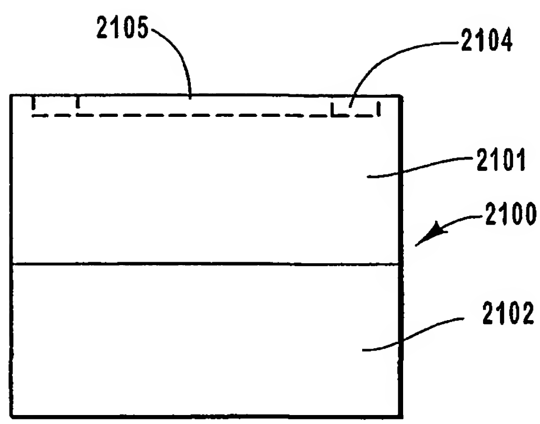

FIG. 21b

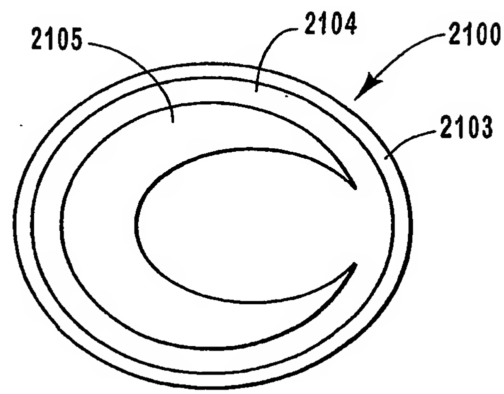

FIG. 21c

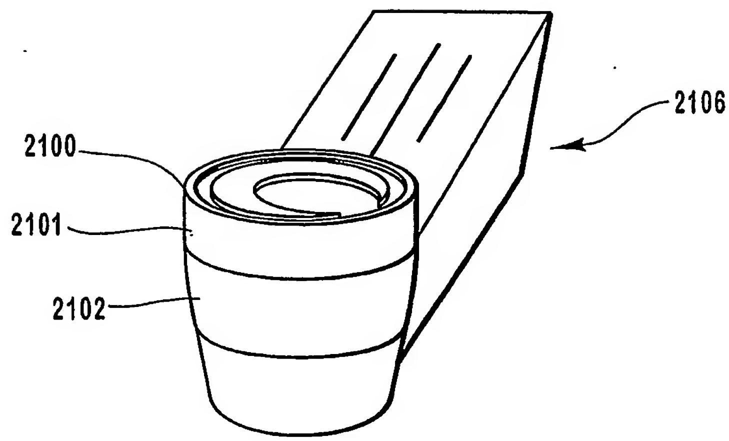

FIG. 21d

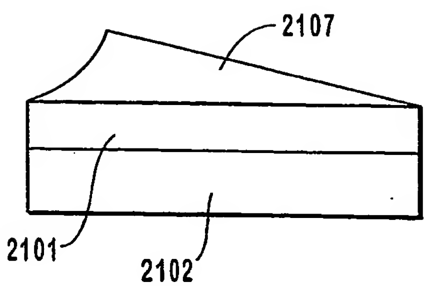

FIG. 21e

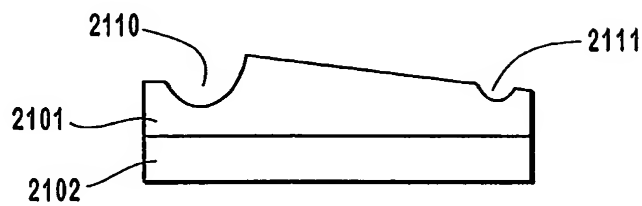

FIG. 21f

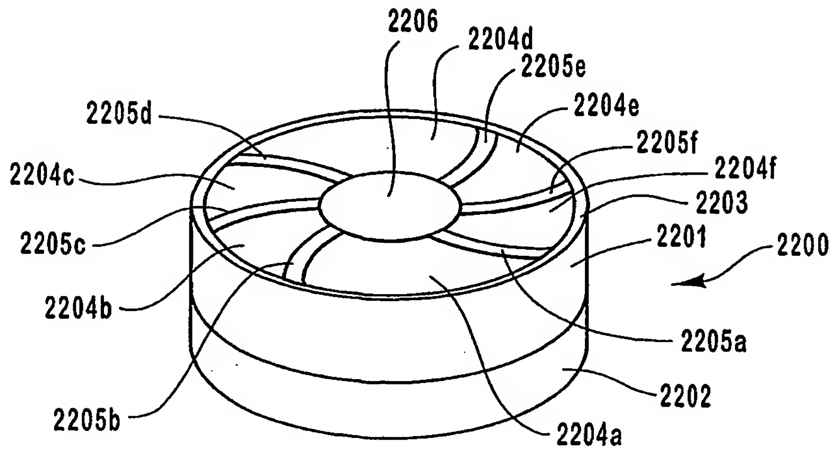

FIG. 22a

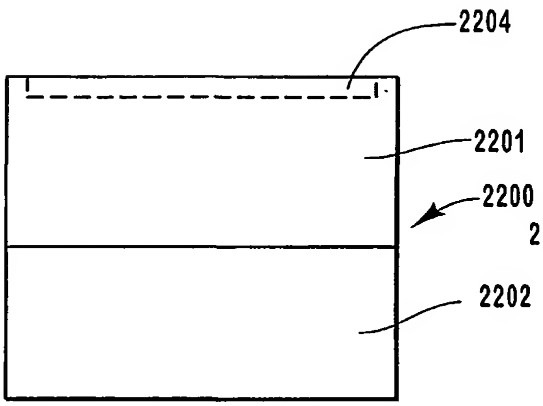

FIG. 22b

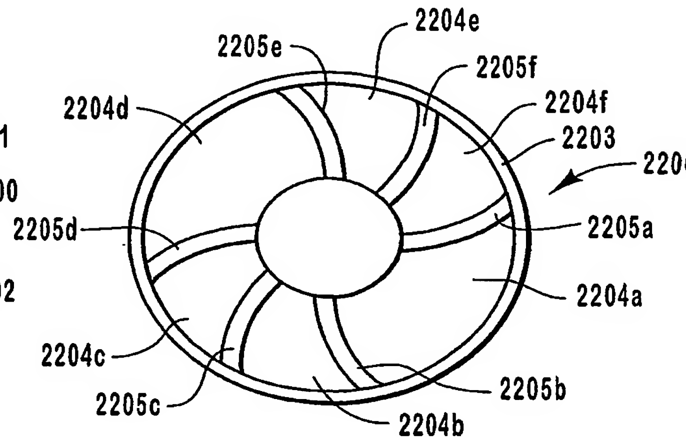

FIG. 22c

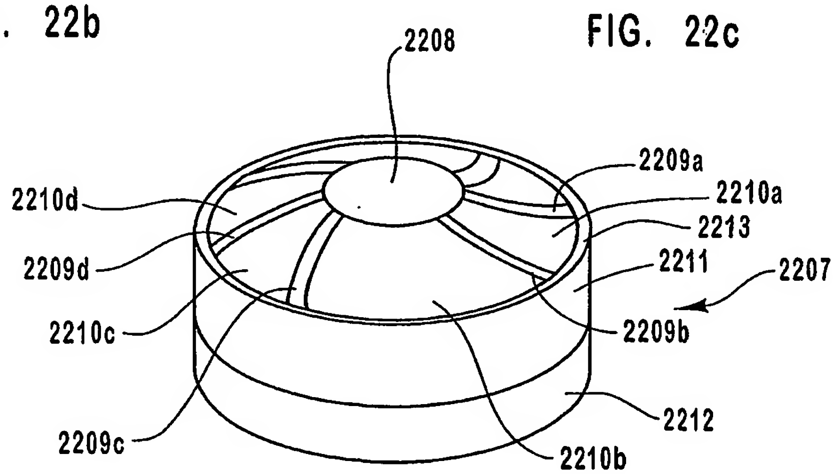

FIG. 22d

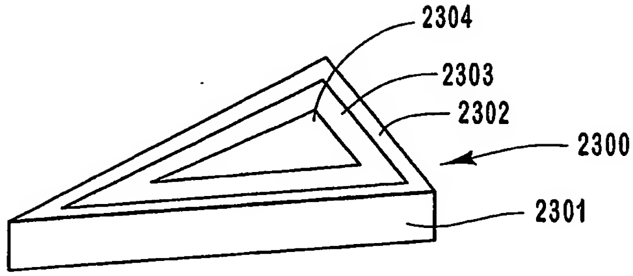

FIG. 23

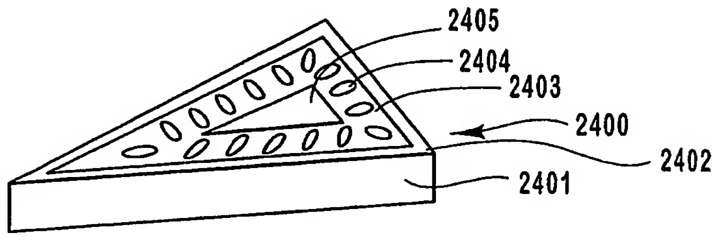

FIG. 24

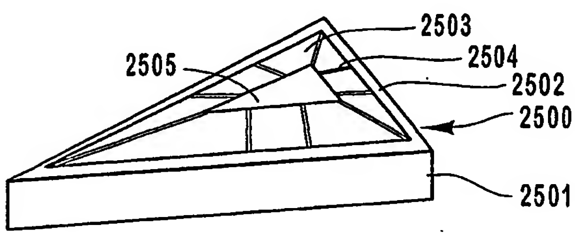

FIG. 25

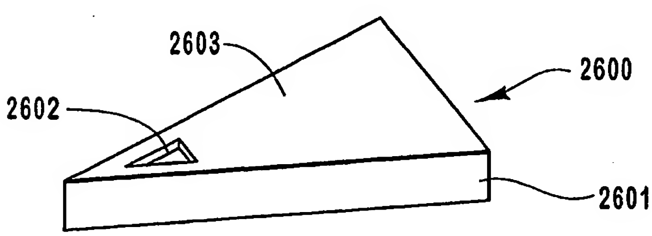

FIG. 26a

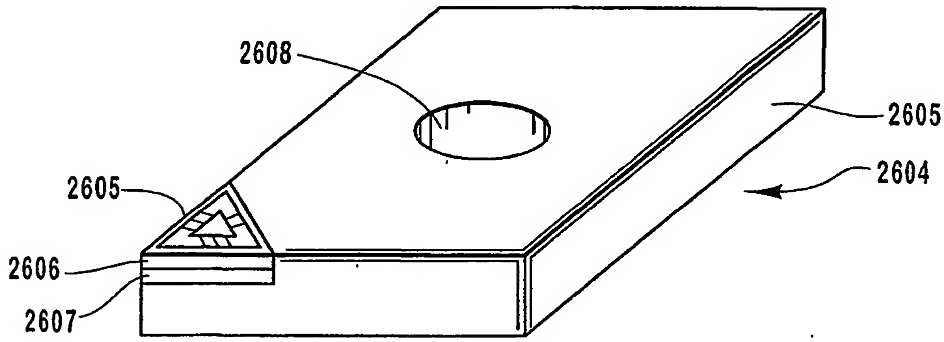

FIG. 26b

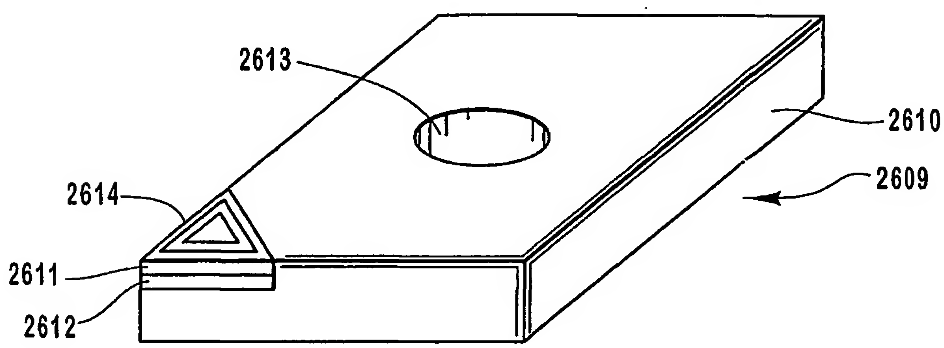

FIG. 26c

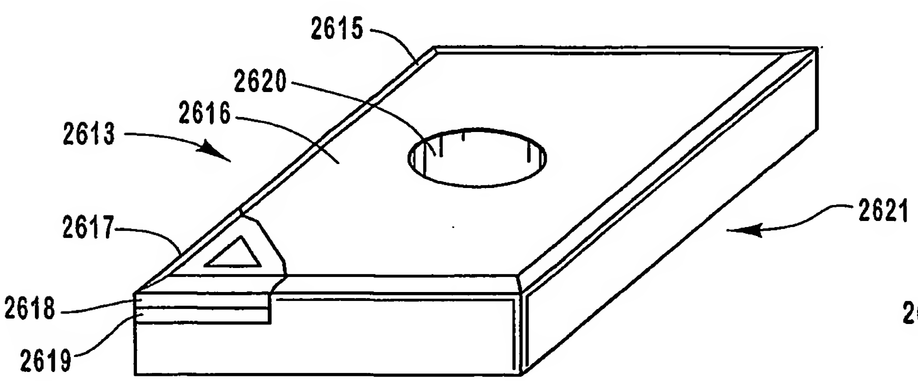

FIG. 26d

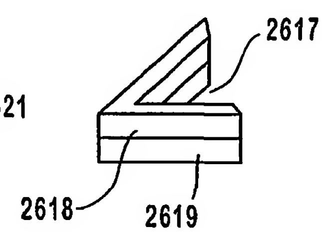

FIG. 26e

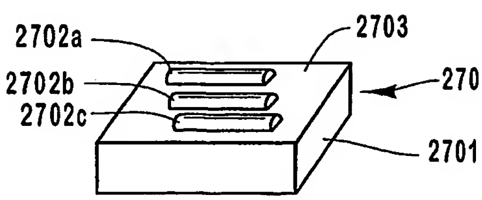

FIG. 27

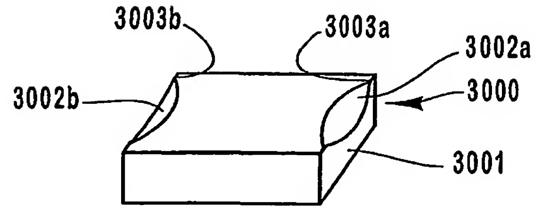

FIG. 30

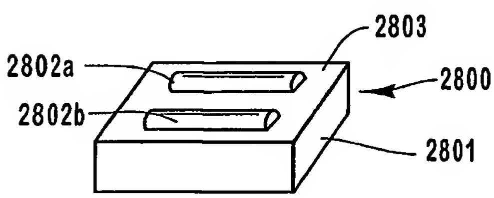

FIG. 28

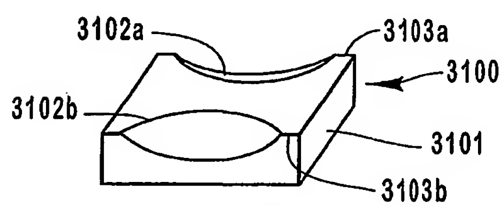

FIG. 31

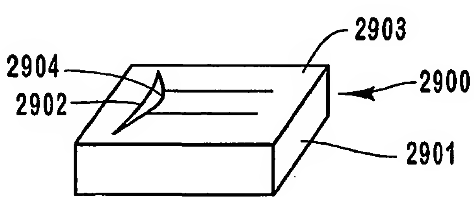

FIG. 29

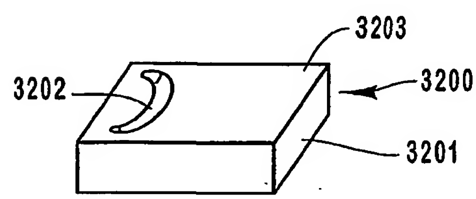

FIG. 32

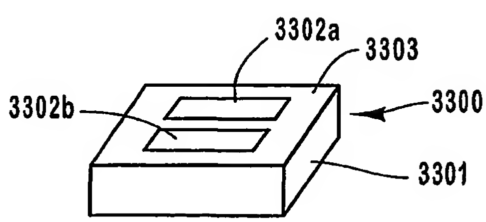

FIG. 33

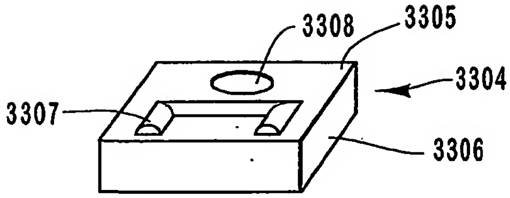

FIG. 33a

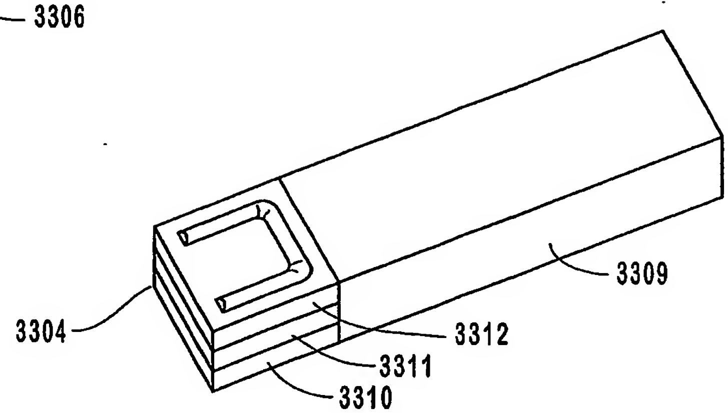

FIG. 33b

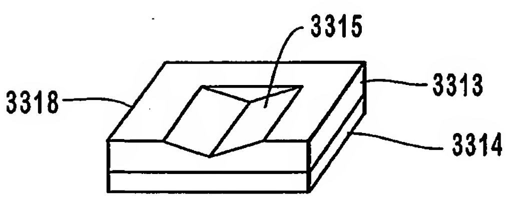

FIG. 33c

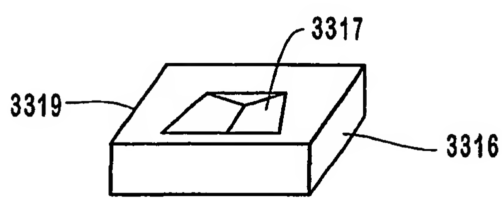

FIG. 33d

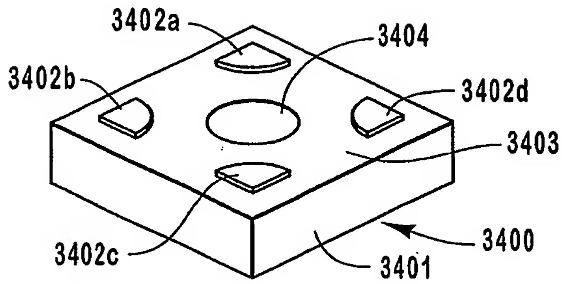

FIG. 34

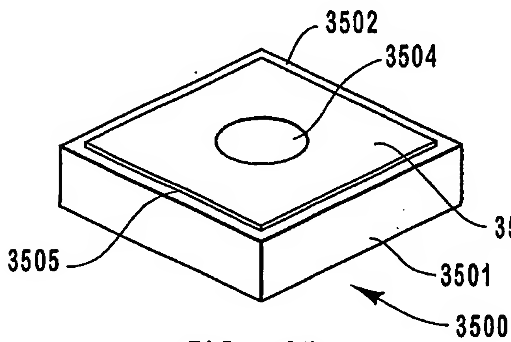

FIG. 35

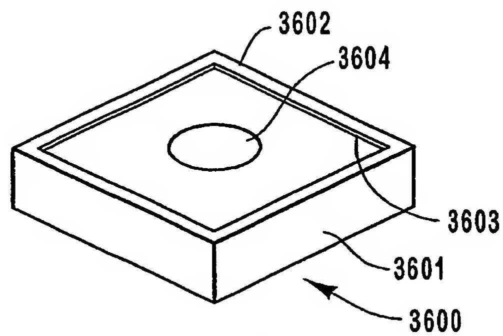

FIG. 36

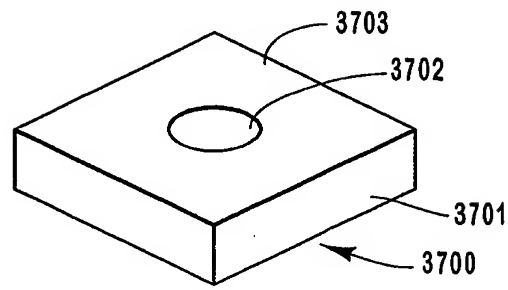

FIG. 37

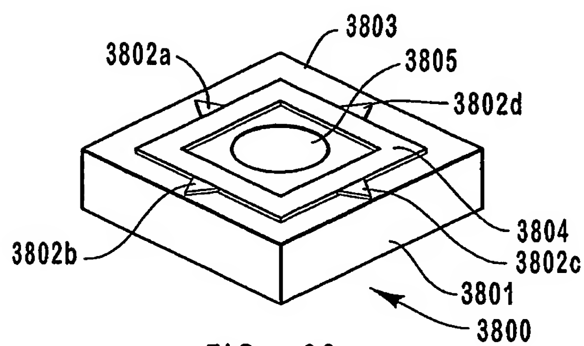

FIG. 38

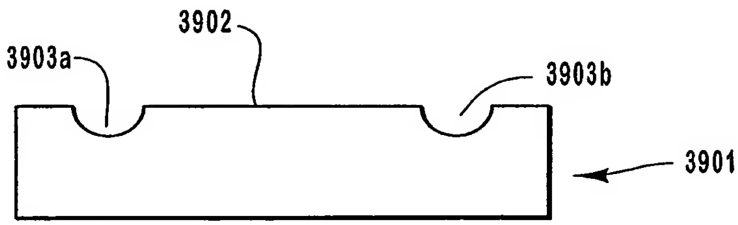

FIG. 39a

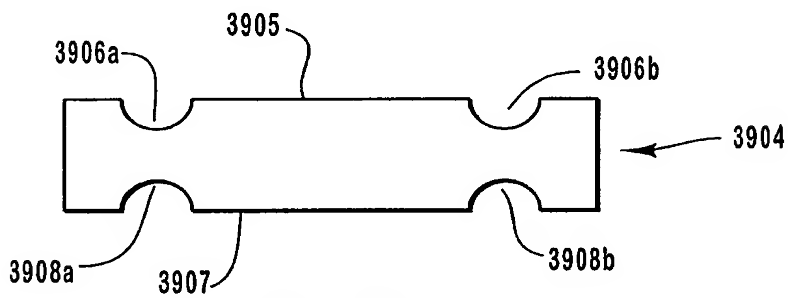

FIG. 39b

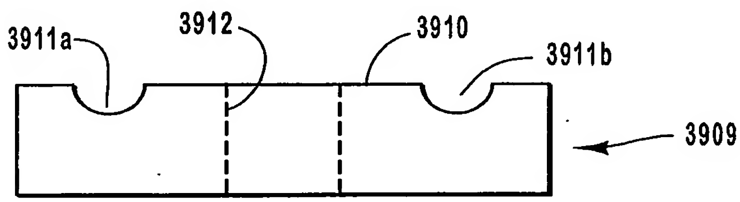

FIG. 39c

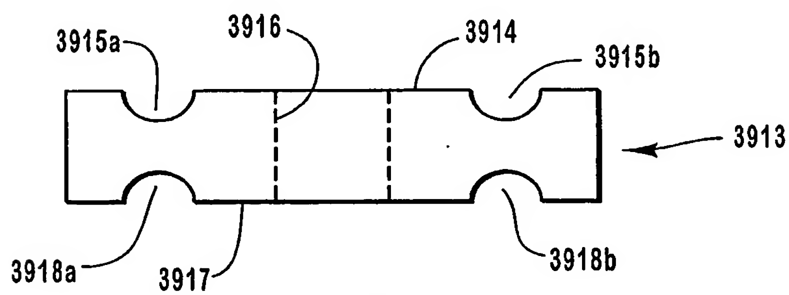

FIG. 39d

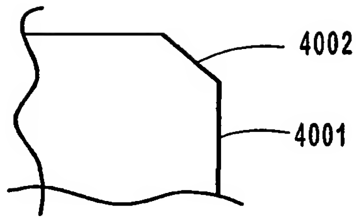

FIG. 40a

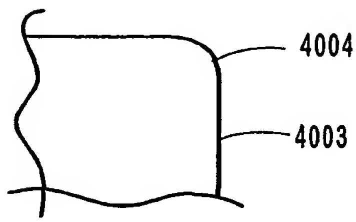

FIG. 40b

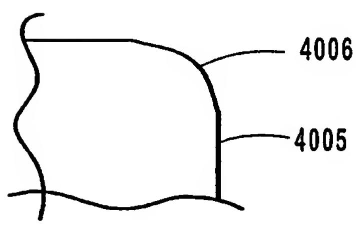

FIG. 40c

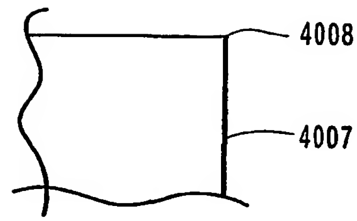

FIG. 40d

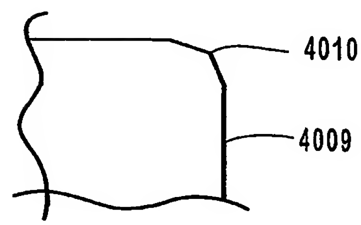

FIG. 40e

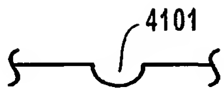

FIG. 41a

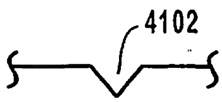

FIG. 41b

FIG. 41c

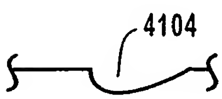

FIG. 41d

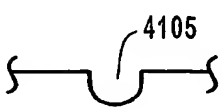

FIG. 41e

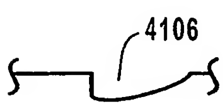

FIG. 41f

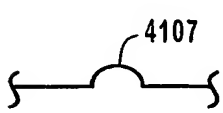

FIG. 41g

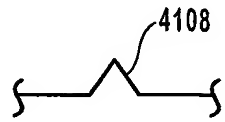

FIG. 41h

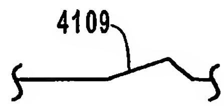

FIG. 41i

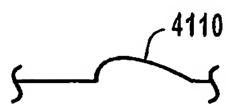

FIG. 41j

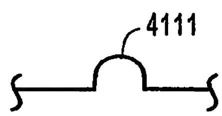

FIG. 41k

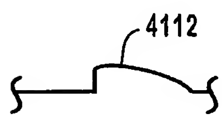

FIG. 41l

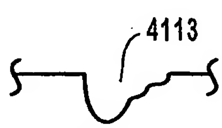

FIG. 41m

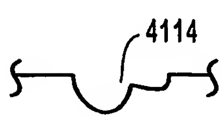

FIG. 41n

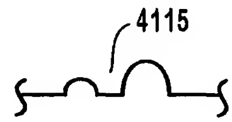

FIG. 41o

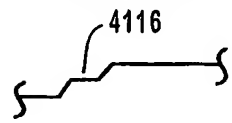

FIG. 41p

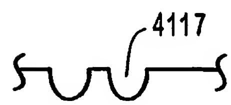

FIG. 41q

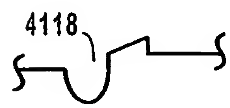

FIG. 41r

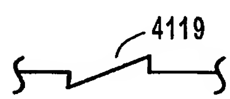

FIG. 41s

FIG. 41t

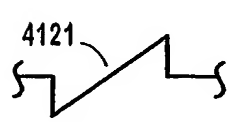

FIG. 41u

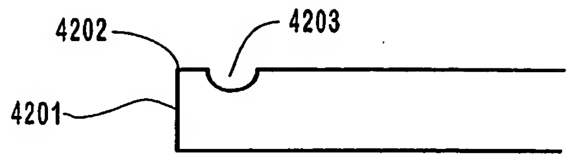

FIG. 42a

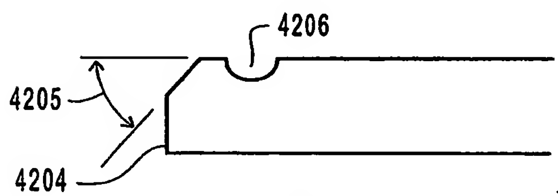

FIG. 42b

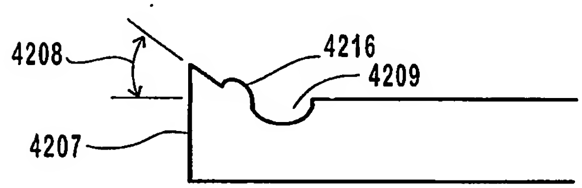

FIG. 42c

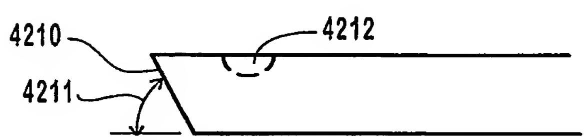

FIG. 42d

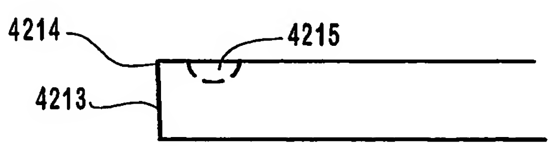

FIG. 42e

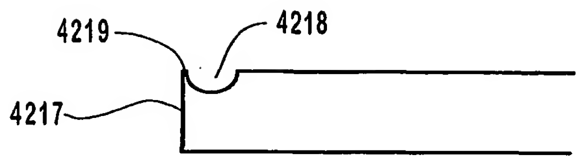

FIG. 42f

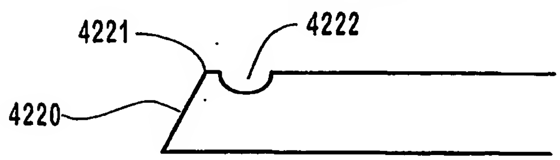

FIG. 42g

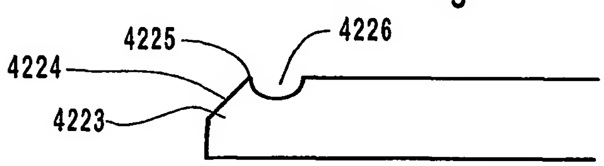

FIG. 42h

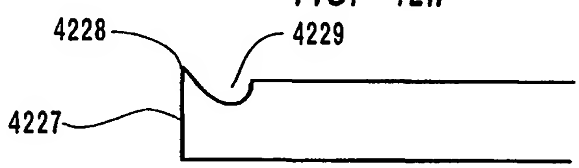

FIG. 42i

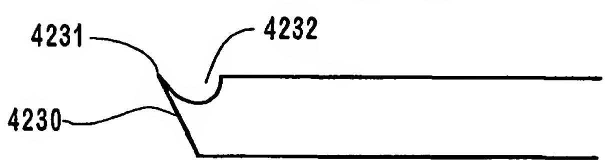

FIG. 42j

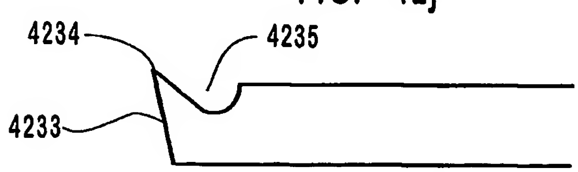

FIG. 42k

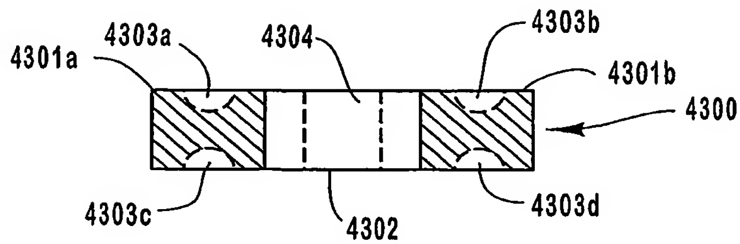

FIG. 43a

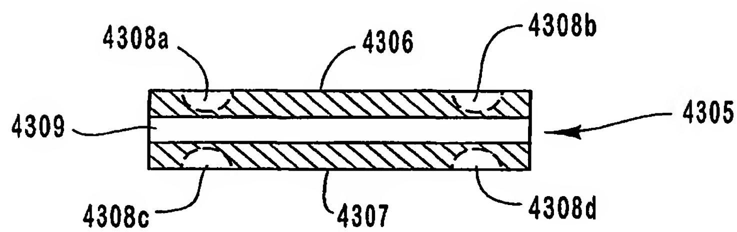

FIG. 43b

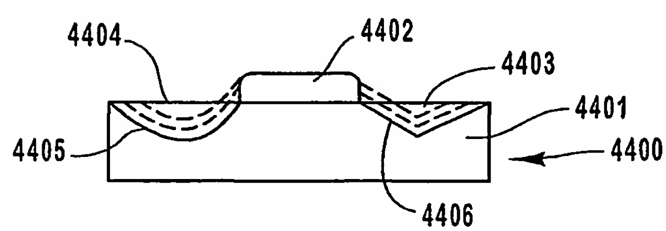

FIG. 44

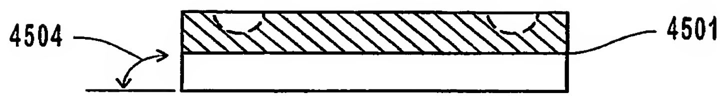

FIG. 45a

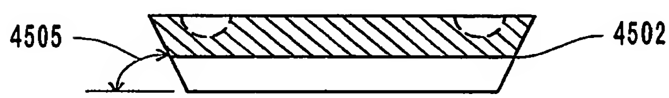

FIG. 45b

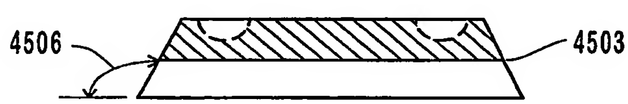

FIG. 45c

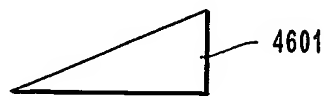

FIG. 46a

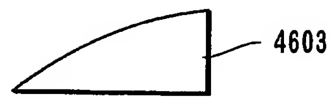

FIG. 46e

FIG. 46i

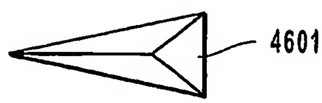

FIG. 46b

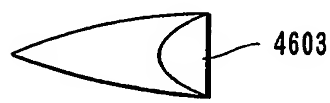

FIG. 46f

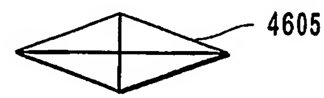

FIG. 46j

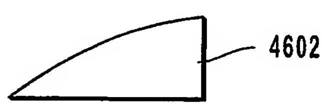

FIG. 46c

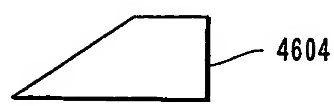

FIG. 46g

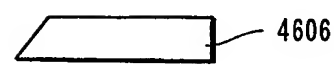

FIG. 46k

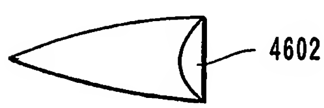

FIG. 46d

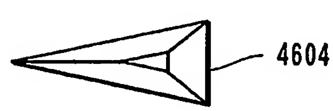

FIG. 46h

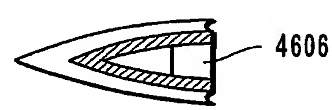

FIG. 46l

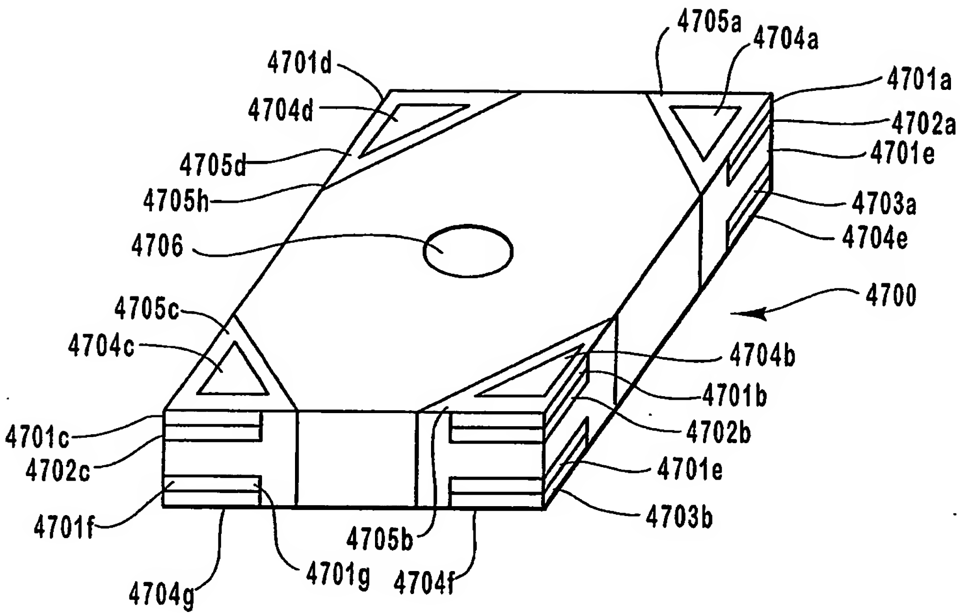
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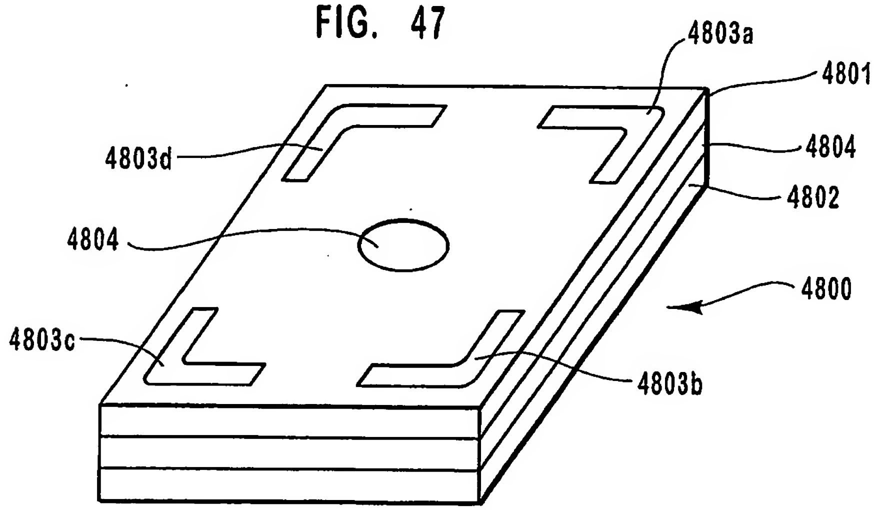
FIG. 47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4803b

FIG. 48

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/04494

A. CLASSIFICATION OF SUBJECT MATTER

IPC(7) :B23B 27/14, 27/22
US CL : 407/114
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 407/114, 115, 116, 118, 119; 408/144, 145

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EAST

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X, P	US 6,106,585 A (PACKER et al) 22 August 2000, see figs. 1 and 6.	1, 3-8, 10, and 11
Y	US 5,525,016 A (PAYA et al) 11 June 1996, see figs. 1a and 1d.	2, 9, and 12-14

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
29 MARCH 2001	26 APR 2001

Name and mailing address of the ISA/US	Authorized officer
Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231	HENRY W. H. TSAI Sheila Veney Paralegal Specialist Technology Center 3700
Facsimile No. (703) 305-3230	Telephone No. (703) 308-7600